AGRICULTURAL ENGINEERING

Published by the AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Executive Office of the Society: Saint Joseph, Michigan.

KARL J. T. EKBLAW, *President* RAYMOND OLNEY, *Secretary-Treasurer*

VOLUME 20 NOVEMBER 1939 NUMBER 11

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Published monthly by the American Society of Agricultural Engineers. Publication office at Benton Harbor, Michigan. Editorial and advertising departments at the executive office of the Society, St. Joseph, Michigan . . . . Price $3.00 a year, 30 cents a copy; to members $2.00 a year, 20 cents a copy. Postage to countries to which second-class rates do not apply, $1.00 additional . . . . The Society is not responsible for statements and opinions contained in papers published in this journal; they represent the views of the individuals to whom they are credited and are not binding on the Society as a whole . . . . Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921 . . . .
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SEPARATING FARMERS FROM DRUDGERY

There is reason for happiness on farms where applied agricultural engineering has provided good living and working conditions, and equipment that does even small power jobs not only easier, but better and more economically than they can be done by hand.

AGRICULTURAL ENGINEERING

VOL 20, NO 11 EDITORIALS NOVEMBER 1939

Fall Meeting Subjects

A PREVIEW of the A.S.A.E. fall meeting program appearing in the news section of this issue, suggests advance consideration of some of the subjects, as a basis for profitable listening and discussion on the part of those who will attend, and as a "next best" in professional development on the part of those who may not find it possible to be present.

* * *

"Farm House Modernization" is one of those extremely personal things about which every farm family has its own ideas. Various surveys have indicated great need and opportunity for such modernization, and some of it is going on all the time. From an agricultural engineering standpoint it involves the technical problem of developing structural improvements, and especially principles as to layout and features which are particularly desirable; and the extension problem of making these principles common knowledge to farmers, farm builders, and farm building supply dealers.

* * *

Pneumatic tires have literally ridden over physical, technical, and economic bumps to a secure place on farm rolling stock. The agricultural engineering problem has progressed from one of determining relative merits, as compared to steel, to a question of what may be best among the wide range of possibilities in pneumatic tire design, application combinations, and economic use practices.

* * *

Interest in farm grain storage gets its impetus, not only from government loan policies and the ever-normal granary program, but also from increased realization that improved and increased farm storage capacity enables growers to perform the added economic services of relieving peak demands on transportation and central storage facilities; of more direct shipment to points of processing or use; of marketing in the form of farm-fed animals and animal products when that proves more profitable than direct sale; and of storage until such time as prices justify sale by covering at least the variable and part of the fixed cost of production. These advantages, together with low farm handling, land, and construction costs stand a fair chance of outweighing the low per-bushel storage costs achieved by the large capacity of central elevators. Basic design, combinations of materials, and structural features for farm storage structures to minimize investment cost per bushel for the life of the structure, depreciation of grain stored, and handling costs of filling and emptying the storage seem to be the main agricultural engineering problems and objectives involved.

* * *

A good start has been made in basic chemical research and in industrial development looking toward increased nonfood uses of farm products. While agricultural engineers have professed an interest in the good cause, their attempts to do something about it have, to date, been limited. The part of the fall meeting program devoted to this subject is designed to stimulate interest, thought, and more specific suggestions as to what agricultural engineers might do to help farmers reach this potential market. We hope to see this session get down to cases in the matter of possible improvements in production economy for old and new farm products for industrial use; new processing equipment and methods technically and economically adaptable to farm application; and industrial requirements and problems relative to specific materials, quantity, quality, uniformity, purity, concentration, chemical stability, physical condition, time of delivery, dependability of supply, cost influences on quantity demand, and any other factors in the industrial supply of organic raw materials which might be improved by engineering applied to farm-source operations.

* * *

The session on "Farm Building Appraisal and Valuation" may reflect increased emphasis on productive value, or the contribution any specific building, by its nature and condition, may be able to make to the type and scale of production for which a farm may be suited by size, topography, soil, climate, water supply, location with respect to markets, and ability and temperament of the operator. For every farm building except the farm house, these factors are becoming more important, and are more difficult to evaluate than first cost and depreciation.

* * *

"Possibilities and Activities of the U. S. Tillage Machinery Laboratory" has been scheduled for the better part of one session to tie theory and practice together more closely in the minds of agricultural engineers both in the equipment industry and in public service research. This laboratory is equipped and staffed to undertake original and highly technical research on the one variable which probably gives field equipment designers greatest trouble, namely, soil. Its work is getting nicely started and can be made of great value by the staff and the potential users of its results getting together on what new information is needed and on interpretation of its technical results.

* * *

While there are no whole sessions on isolated phases of soil and water conservation, we note in the program of this division a predominance of research reports, interpretation of results, discussion of techniques and equipment, and planning based on research results. This seems to reflect the new support of, and concentration of interest in, a scientific approach to the control and management of water in the forms, quantities, and phenomena which represent farm problems in soil conservation and crop production.

* * *

In the Rural Electric Division interest seems to have shifted somewhat from extension methods and toward the technology of old and new farm application problems and opportunities. Apparently farm acceptance of electric power, in principle, has shifted the agricultural engineering problem in farm electrification in the direction of checking and improving present applications, and of developing new applications that can be justified technically and economically. As a working philosophy, every electrical phenomenon might be considered a potential aid to farm practice, and every farm operation or function susceptible to improvement by application of electricity for light, power, heat, automatic control, or other useful effect.

* * *

Space does not permit mention of all individual papers scheduled, but a review of the program should suggest unanswered questions and profitable lines of thought to all open-minded agricultural engineers.

Quantitative Economics

CAN ENGINEERS think their way to more quantitative concepts of economic relationships, at least as a guide to their own professional practice and personal business dealings? It has frequently been suggested and seems a likely field for mental exercise, to say the least. If so, agriculture's position as one problem center in the current economic situation seems to justify some thought in this direction by agricultural engineers.

To give one example—as a bid for the ideas of agricultural engineers—we have tried to think quantitatively of relationships between production, consumption, and saving within the United States as a fairly complete and independent trade area, and have arrived at a tentative conclusion which gives strong support to some previous engineering viewpoints, if our logic will withstand critical scrutiny.

This tentative conclusion is that production and consumption may be best balanced, with resulting maximum employment, creation of new wealth, and opportunity for effective saving, when total income for any unit of time is so divided between spending and saving that effective buying power for consumer goods is sufficient to absorb all the consumer goods produced, within limits as to desirable quantity, quality, and human use value.

Conversely, attempted saving, to the extent that the remaining buying power for consumer goods cannot or does not absorb the production of such goods, defeats its purpose to the extent that the earning power and effective value of this saving and of previously saved wealth are decreased by reduced consumption and reduced use and value of production capacity.

The elementary economic concepts and quantitative extensions thereof, by which we arrive at the above tentative conclusions are, briefly, the following:

The object of production is consumption.

Wealth is a store of values for human use, and exists largely in the form of natural resources and production equipment.

Production is of two kinds, namely, consumer goods and services and producer or capital goods.

Labor, management, and capital all contribute to both of these kinds of production. The sum of their contributions is income or total wealth produced in any unit of time and area. In any one year in the United States it is our annual national income.

This produced wealth is divided in use between spending and saving.

That which is allocated to spending becomes effective buying power for consumer goods.

That which is allocated to saving goes, for the most part, where there is most room for it—into the form of producer or capital goods.

That which is invested in capital goods is effectively measured, not by the original investment, but by capitalization of its earning capacity or contribution to production.

Since the cost of consumer goods is the sum of all values contributed to them, it is equal to the income arising from their production, and if they are to be bought and consumed, this proportion of total income is not available for saving.

The proportion of total income which is available for saving, then, is the amount created by the production of capital goods.

But producers of capital goods are also consumers. The opportunity for saving on the part of producers of consumer goods, without depleting necessary buying power for consumer goods is, therefore, the result of and equal in amount to the effective buying power for consumer goods which is created in the production of capital goods.

When there is a tendency to spend more for consumer goods than the values created in their production, inventories are lowered, prices tend to rise, more production capacity is used, income from investment increases, and inducement to save is increased, tending to restore balance.

Likewise, when there is a tendency to save more than the values created in production goods, at the cost of lowered consuming capacity, decreased consumer demand is reflected in decreased use of production capacity, decreased income from existing investment, decreased market for new producer goods, decreased employment in producer goods industries, further decreased buying power for consumer goods, increased idle funds in banks, and investment losses which more than cancel the attempted extra savings. This tends to reduce the possibility and attractiveness of saving, but until it is more generally understood, is not sufficient to restore attempted saving to its practical limits.

What are some of the implications of the above line of logic, if it can be so dignified?

It suggests that effective buying power for consumer goods is a limiting factor in the prosperity of an industrial economy. It suggests that this buying power may be increased within the limits of total income by more widespread understanding of the futility of trying to save more than the proportion of total production which can be saved and given value by maintained spending, economic consumption, and use of production capacity.

It lends weight to the belief that effective buying power for consumer goods can be further increased by adding to the variety, quality, utility, and attractiveness of available consumer goods and services and by decreasing their cost, as added inducement to consume. This, in turn, suggests research and development work on products and production equipment as a highly desirable and profitable form of investment for the proportion of income which is surplus over what is needed to absorb consumer goods.

It supports the merit of capital goods as a direct contributor to buying power for consumer goods, as well as to production, to the same extent, of goods available for consumption. It further supports the merit of capital goods as the substance of economic saving for security, by individuals and corporations.

It strengthens the arguments in favor of high production efficiency, in that the capital goods which increase man's capacity to produce not only give him more goods, buying power, and time for consumption, but more opportunity for saving.

As applied to farmers and to agricultural engineering it supports the merit of good buildings and equipment, conservation of resources, home comforts and conveniences, efficient production, and efforts to expand industrial use of farm products.

These implications seem important enough that, if our reasoning is wrong in principle, it is worth disproving; if it errs in detail, it is worth correcting; and if it is substantially supportable, it seems worthy of extension. We submit it as a possible stimulus to profitable engineering thought, and invite consideration of its possible merit as a concept which might help to improve the effectiveness of and general satisfaction with the economic system of free enterprise.

Transport Wheels for Agricultural Machines

I. Comparative Performance of Steel Wheels and Pneumatic Tires on Two Manure Spreaders of the Same Model

By E. G. McKibben and H. J. Thompson

FELLOW A.S.A.E. JUNIOR MEMBER A.S.A.E.

THE investigations which furnish the data reported in this paper were undertaken because it seemed logical to supplement the detailed studies of individual wheels by tests of at least one pair of complete machines (See Figs. 1 and 5 and Table 1). The principal tests used and the general results obtained are given in the following summary.

SUMMARY

1 The comparative performance of steel wheels and pneumatic tires on two manure spreaders of the same model were investigated from the standpoints of rolling resistance, shock, breakage, and wear.

2 Comparative rolling resistance tests by means of a ratio dynamometer (See Figs. 1 and 2) were made on ten road and soil conditions ranging from a concrete road to a fall-plowed field thawed to a depth of 12 in.

3 The decrease in draft resulting from the use of pneumatic tires varied from 4 to 335 lb, with a mean of 312 lb, or 5 to 67 per cent, with a mean of 44 per cent (See Table 2).

4 The shock characteristics of these two types of transport wheels while traveling over five miles of gravel roads were studied by means of a contact accelerometer for the three speeds of 2.5, 5, and 10 mph (miles per hour).

5 The ratios of the number of shocks, of a given magnitude, received by the machine with steel wheels to those received by the machine with pneumatic tires averaged 4.7, 41.8, and 50.3, respectively, for the three speeds.

6 Extreme shocks of over 10,000 lb were recorded for the steel wheels at the highest speed (See Table 3).

7 In order to compare breakage and wear a 1,000-mile road test was run over a five-mile course of gravel—200, 200, and 600 miles, respectively, at 2.5, 5, and 10 mph (See Fig. 5).

8 There were no difficulties with the spreader equipped with pneumatic tires, except the loosening of a few nuts, while indications of breakage appeared on the other spreader soon after the start of the 5-mph tests. (See Table 5 for a list of failures.)

TABLE 1. WHEEL EQUIPMENT AND GROSS LOADS[a] USED

	Manure spreaders[b]	
	With steel wheels	With rubber tires
Rear wheel size, in	6.5x40	7.50–24
Rear tire inflation pressure, lb	——	28
Rear wheel loads[a], lb	1250	1250
Front wheel size, in	5x27	5.50–16
Front tire inflation pressure, lb	——	20
Front wheel loads[a], lb	750	750

[a]Machines were loaded with sacked gravel to these gross loads per wheel, making total gross loads of 4000 pounds.

[b]Model 8 New Idea furnished through the courtesy of New Idea, Inc.

Journal Paper No. J-692 of the Iowa Agricultural Experiment Station. Project No. 576, in cooperation with the American Society of Agricultural Engineers.

The authors are, respectively, associate professor of agricultural engineering, Iowa State College; and research fellow, Iowa State College, 1938-39, and now junior agricultural engineer, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.

TABLE 2. ROLLING RESISTANCE OF TWO MANURE SPREADERS OF THE SAME MODEL, ONE EQUIPPED WITH STEEL WHEELS AND THE OTHER WITH RUBBER TIRES[a]

Soil Condition	Decrease in draft resulting from rubber tires, per cent[b]	Draft of spreader with steel wheels, lb	Decrease in draft, lb
Concrete road	5	80[c]	4
Fall plowing, thawed to depth of 8 to 12 in	20	600[c]	120
Bluegrass sod[e]	30	400[c]	120
Temporary road across fall plowed field[d]	40	425[c]	170
Burned sweet clover stubble[e]	45	400[c]	180
Winter rye, rough and frozen	50	180[d]	90
Sweet clover stubble, rough, frozen, covered with 4 in of snow and slush	60	215[d]	129
Gravel road	60	150[d]	90
Cinder road	65	175[d]	114
Fall plowing, rough, 4 in of mud on surface, frozen underneath	67	500[d]	335
Mean	44	312	135

[a]See Table 1 for description of wheels and tires.

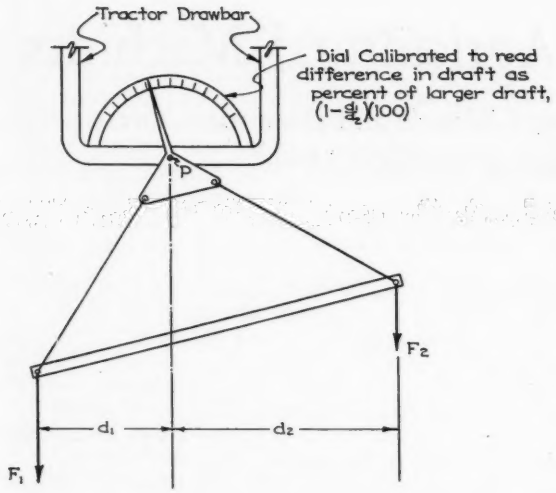
[b]Determined by the ratio dynamometer shown in Figs. 1 and 2.

[c]Estimated from the performance of individual wheels on similar soil conditions.

[d]Obtained by averaging several readings of an indicating dynamometer.

[e]Per cent moisture, on dry basis, 25 to 30.

Fig. 1 Determining the relative rolling resistance of two manure spreaders by means of the ratio dynamometer shown in Fig. 2.



$F_1 d_1 = F_2 d_2$, $F_2 = F_1 \frac{d_1}{d_2}$

Fig. 2 Principle of the ratio dynamometer used to obtain the data of Table 2 (Fig. 1). This apparatus was built for one of the 1938 Field Day demonstrations at Iowa State College by C. H. Youngberg

9 The ratios of front axle deformation, loss of weight by front wheels, loss of weight by rear wheels, loss of weight by front-wheel bearing, and wear of front bearings were 3.4, 12.3, 14.6, 2.8, and 2.2, respectively.

10 The annual cost of use of a set of tires for a conventional manure spreader is estimated to be about 15 dollars or 60 cents per day for 25 days of annual use.

TABLE 3. NUMBER OF SHOCKS OF VARIOUS MAGNITUDES RECEIVED BY FRAME AT REAR WHEEL OF MANURE SPREADERS DURING FIVE MILES OF TRAVEL OVER GRAVEL ROADS AT THREE DIFFERENT SPEEDS

Speed, mph	Shock,[a] lb	Number of Shocks (5-mile run) Steel wheels	Rubber tires	Ratio[b]
2.5	350	3,609	403	9.0
2.5	850	703	259	2.7
2.5	1,288	111	47	2.4
2.5	1,825	6	0	——
2.5	1,988	2	0	——
			Mean	4.7
5	1,050	8,598	283	30.4
5	1,550	4,407	138	31.9
5	2,050	3,272	77	42.5
5	2,300	1,621	26	62.4
5	2,838	274	2	——
5	3,425	89	2	——
			Mean	41.8
10	2,250	3,581	174	20.6
10	2,818	2,818	89	31.7
10	3,850	2,044	35	58.4
10	4,550	1,721	19	90.6
10	5,250	208	7	——
10	5,988	88	3	——
10	7,262	53	0	——
10	9,138	25	0	——
10	10,375	4	0	——
10	10,688	1	0	——
			Mean	50.3

[a] Shock caused by impact. These forces are in addition to the dead load of 1250 lb.

[b] Ratios of number of shocks received by the two spreaders. These ratios are not shown where the number of shocks received by the rubber-tired spreader was less than ten.

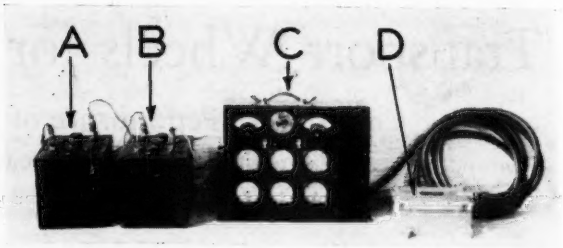


Fig. 3 Six element contact accelerometer used to obtain the impact data of Table 3. This instrument was available through the courtesy of the Firestone Tire and Rubber Company

11 Under many conditions this cost appears to be well justified.

Ratio Dynamometer. The problem of determining comparative rolling resistance was considerably simplified by using the ratio dynamometer shown in Figs. 1 and 2. This is a very simple device consisting of a triangular evener and a calibrated dial. It is quite effective, however, and also lends itself well to demonstrations. In fact, for emergency determinations a simple triangular evener without a dial can be used, in which case the distances shown as d_1 and d_2 of Fig. 2 must be measured directly.

In operation the end of the evener to which the greater load is attached must drop back until the moments about point P attain equilibrium, that is until

$$F_1 d_1 = F_2 d_2 \qquad [1]$$

Solving this equation for F_2,

$$F_2 = F_1 d_1 / d_2 \qquad [2]$$

The decrease of F_2 from F_1 is $F_1 - (F_1 d_1 / d_2)$.

The per cent decrease of F_2 from F_1 is

$$(F_1 - F_1 d_1/d_2)\,(100/F_2) = (1 - d_1/d_2)\ (100) \qquad [3]$$

The dial was calibrated in terms of this relationship and thus gave directly the per cent decrease in rolling resistance resulting from the use of pneumatic tires.

If absolute as well as relative values are desired, it is necessary, of course, to use a conventional dynamometer on one of the loads. It is also necessary to correct for grade unless tests are run on a level surface.

Rolling Resistance. Comparative rolling-resistance trials using the ratio dynamometer were made on the ten road and soil conditions described in Table 2 which varied from concrete to 12 inches of mud in a recently thawed fall plowed field. The decrease in rolling resistance varied from a minimum of 5 per cent on concrete to a maximum of 67 per cent on rough partly frozen fall plowing. The mean for the ten trials was 44 per cent, and for the conditions which probably represent the range of usual operation decreases in draft ranged from 30 to 50 per cent.

The average decrease in draft was 135 lb, which is equal to 0.9 hp at the horse speed of 2.5 mph, or 1.8 hp at a tractor speed of 5 mph.

Contact Accelerometer. A six element solenoid type contact accelerometer[1] was used to study the comparative shock characteristics of the two types of wheels. The complete apparatus is shown in Fig. 3. A and B are six-volt automobile batteries, one for the solenoid circuit and one for

[1] Supplied by the Firestone Tire and Rubber Co. Research series bulletin No. 44 by H. M. Jacklin and G. J. Liddell of the Engineering Experiment Station, Purdue University, gives a good description and analysis of several types of accelerometers.

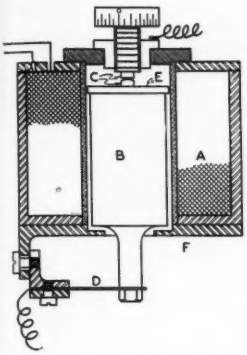


Fig. 4 Cross section of one of the six sensitive solenoid elements of the Firestone contact accelerometer shown in Fig. 3. A, solenoid winding; B, actuating weight; D, spring to balance action of gravity on B; C, contacts in counter circuit which separate when the action of acceleration is large enough to overcome the opposing solenoid magnetic field also acting on B

the counter-circuit; C is an instrument panel on which are mounted a voltmeter, ammeter, switches, and six electric counting clocks; and D is a metal case containing six sensitive solenoid elements of the type shown in Fig. 4.

This case is mounted at the point where acceleration is to be determined. The solenoids in each of the six elements have a different strength, thus making it possible to count the number of shocks corresponding to each of six levels of acceleration.

Impact Studies. Impact or shock tests using the instrument just described were made over a five-mile course of gravel road at each of three speeds, 2.5, 5, and 10 mph. In these studies the case containing the solenoid elements, D of Fig. 3, was mounted at the side of the spreader frame just over the rear axle.

The data obtained are given in Table 3. The figures of the second column of this table were obtained by substituting the accelerometer readings and the weight of the rear wheel load in the equation

$$\text{Force} = (\text{Acceleration})\,(\text{weight}/32.2) \qquad [4]$$

The ratios of number of shocks of a given magnitude received by the two machines varied from 2.4 to 90.6 with most of the values above 20. As would be expected, the magnitude and number of shocks increased rapidly with speed, particularly for the machine equipped with steel wheels. At the highest speed the shocks ran as high as 10,000 lb for this machine, or nearly twice the maximum shock recorded for the other machine. These data are ample

TABLE 4. CONDITION OF 5-MILE COURSE ON GRAVELED ROAD[a] DURING 1000-MILE ROAD TEST

	Miles traveled over various road conditions						
	Dry		Wet		Snow		
Speed, mph	Frozen	Unfrozen	Frozen	Unfrozen	Frozen	Melting	Total
2.5	25	80	25	25	15	30	200
5.0	60	35	5	20	80	—	200
10.0	145	205	80	120	20	30	600
Total	230	320	110	165	115	60	1,000
Per cent	23.0	32.0	11.0	16.5	11.5	6.0	——

[a]This road was well maintained, subject to only moderate traffic, and in good condition during all tests.

Fig. 5 Arrangement used for road test of the two manure spreaders. (See Tables 1 and 4 for description of spreaders and road, and Tables 5 and 6 for results of the tests.) The positions of the manure spreaders were reversed at regular intervals

TABLE 5. FAILURES OCCURING DURING 1000 MILES OF TRAVEL ON GRAVEL ROAD AT THE SPEEDS INDICATED[a]

Distance at speed of 2.5 mph	5 mph	10 mph	Failure[b]
200	——	——	Loose nuts on five main frame bolts[c]
200	——	25	Spokes started to loosen in all rims
200	——	87	Broken rear wheel rim weld[d]
200	200	100	Loose nuts on five main frame bolts[e]
200	200	130	Broken chain-guard bracket
200	200	135	Broken chain-guard
200	——	200	Bent spoke in rear wheel
200	200	200	Two broken bolts in distributor frame
200	200	200	Loose nuts on three main frame bolts[e]
200	200	300	Broken rivet in front axle pivot plate
200	200	305	Lost grease fitting pipe on rachet shaft bearing
200	200	306	Lost set collar from left end of distributor
200	——	327	Broke lug holding ends of broken rear
200	200	345	Lost setscrew from collar on control rod wheel rim
200	——	352	Broken spoke in rear wheel. After another quarter mile another spoke broke and rear wheels were replaced
200	200	346	Broken grease fitting pipe on left end of beater
200	200	460	Two broken rivets in front-axle pivot plate
200	200	532	Lost two grease fittings on distributor
——	200	106	Spokes loosened in second set of rear wheels
200	——	592	Broken spoke in front wheel
200	200	600	Side boards worn to depth of 1/8-in by gravel used for loading[f]

[a]See Tables 1 and 4 and Fig. 5 for descriptions of equipment, loads, and roads.

[b]Except for loosening of nuts on main frame bolts as given in notes "c" and "e", all failures occurred on the spreader equipped with steel wheels.

[c]Loose nuts on three main frame bolts of the spreader equipped with pneumatic tires.

[d]Traction lug across broken weld prevented complete failure.

[e]Both spreaders.

[f]On the rubber-tired spreader this wear was little more than enough to remove the paint.

explanation of the differences in breakage and wear reported later.

Road Tests. In order to obtain data on the effect of these impact differences on breakage and wear under severe operating conditions, a 1000-mile road test was made over the same five-mile course of graveled road. The machine arrangement used during this test is shown in Fig. 5.

Before starting the tests corresponding bolts on the two machines were tightened to the same tension by using a torque wrench. All wheels were carefully weighed and the front-wheel spindle diameters were measured with a micrometer caliper. These weights and dimensions were checked at frequent intervals during the test.

The positions of the two spreaders were reversed after each trip around the course and careful attention was also given to adequate and equal lubrication of the front-wheel and rear-axle bearings of both machines.

Road. The course chosen was a gravel road rather well maintained and subject to only moderate traffic. Since the test was started January 19 and completed April 3, the road was frozen nearly half the time. The miles traveled over different road conditions at the different speeds are given in Table 4.

Speeds. The first 200 miles was run at 2.5 mph, the second 200 miles at 5 mph, and the remaining 600 miles at 10 mph. In order to maintain these slow speeds with satisfactory accuracy, the speed of the speedometer drive on the

TABLE 6. FRONT AXLE DEFORMATION AND WHEEL AND BEARING WEAR DURING ROAD TESTS[a] OF TWO MANURE SPREADERS OF THE SAME MODEL, ONE EQUIPPED WITH STEEL WHEELS AND THE OTHER WITH PNEUMATIC TIRES

	Spreader with steel wheels	Spreader with pneumatic tires	Ratio
Permanent deformation of front axle, in	0.31	0.09	3.4
Loss of weight[b] by front wheels, lb	3.44	0.28	12.3
Loss of weight[b] by rear wheels, lb	6.70	0.46	14.6
Loss of weight[c] by front-wheel roller bearings, lb	0.098	.035	2.8
Wear of front-wheel spindle[d], in			
Average	0.011	.005	2.2
Maximum	0.021	.008	2.6
Rockwell hardness, B scale[e], of front-wheel spindle			
Mean	98.6	97.6	1.0
Maximum	103.0	101.5	1.0
Minimum	93.5	92.0	1.0

[a]One thousand miles on gravel road; 200 miles at 2.5 mph; 200 miles at 5 mph; and 600 miles at 10 mph. See Tables 1 and 4 for descriptions of spreaders, wheels, loads, and road.

[b]Total for two wheels.

[c]Total for four plain roller bearings.

[d]Right spindles only; there was too much difference in the hardness numbers of the two left spindles to allow a satisfactory comparison.

[e]The aproximate equality of these numbers for the two spindles indicates essentially equal hardness, while the slightly smaller values for the spindle on the rubber-tired spreader is evidence that the decreased wear on this spindle was not the result of greater hardness. Thirty-two hardness determinations were made on each spindle.

towing truck was increased by inserting a pair of gears with a 10-to-1 ratio.

Breakage. The failures observed during this 1000-mile road test are given in Table 5. All failures recorded in this table, except the loosening of nuts on main frame bolts, occurred only on the machine equipped with steel wheels.

During the first 200 miles at 2.5 mph, there were no failures except the loosening of nuts on main frame bolts as already noted. While there was no breakage during the 200-mile run at 5 mph, signs of failure such as the loosening of spokes in the steel wheels appeared soon after the start of this part of the test.

The breakage which occurred during the 600 miles at 10 mph indicated the unsuitability of steel wheels for this type of service. In spite of these failures, however, the record made during this test by the steel wheels and the machine on which they were used, was very good indeed and was in fact a credit to the designer and manufacturer.

Wear. The loss of weight by the front and rear wheels and front-wheel bearing, as well as the wear of the front-wheel spindles, are given in Table 6. This table also includes a comparison of the permanent deformation of the front axles. The wear on the rubber tires was hardly noticeable, while the cleats on the rear steel wheels were badly worn.

A satisfactory wear comparison could be made for the right front-wheel spindles, because they were found to be of the same hardness. The left spindles, however, differed so much in hardness that a comparison of the wear would have little meaning.

Changes in the rate of spindle wear as the test progressed are shown in Fig. 6. Rapid wear at the beginning of the test is probably the result of initial roughness of the spindle surface. The rate of wear for the steel at 10 mph was noticeably increased.

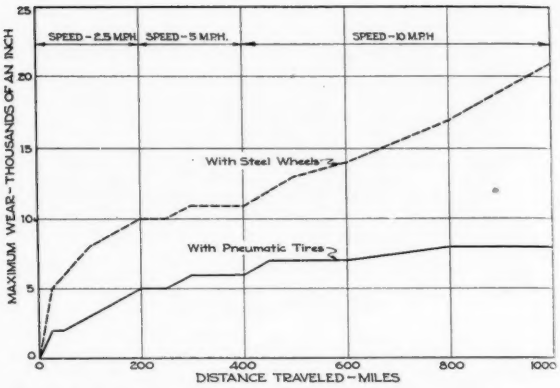


Fig. 6 Maximum wear of right front-wheel spindles of two manure spreaders, one with steel wheels and the other with pneumatic tires, during travel over 1,000 miles of gravel road. (See Tables 1 and 4 and Fig. 5 for description of spreaders and road)

Steel Wheels. One front and one rear wheel had flanged and the others had flat rim cross sections. In order to subject both types to the same use, they were shifted from side to side at regular intervals. Although the wear was approximately the same for the two types of steel wheels, all failures, except a slight loosening of the spokes in the rims, occurred on the wheels with flat rim cross sections.

Cost of Use of Rubber Tires. It is impossible to make definite statements concerning the cost of use of rubber tires on a machine such as a manure spreader because of the lack of information concerning the length of useful life to be expected. Data on the life of tractor tires[2] suggests a ten-year life as a reasonable expectation. Assuming this life and using an interest rate of 6 per cent and 1 per cent repair rate, the annual cost, on the sinking fund basis of a set of tires costing $100, would be approximately $15. If the assumption as to useful life is reduced to 5 years, the estimated annual cost is increased to $25.

The average annual use of manure spreaders is about 25 days according to studies in Iowa[3] and Indiana[4]. Thus the added cost per day would be about 60 cents on the basis of a 10-year life, or one dollar on the basis of the shorter life of 5 years.

If a tractor is used, if the haul is long, or if an appreciable part of the travel is over graveled roads or lanes, these costs are easily justified. This conclusion would also hold if field conditions were such that a steel-wheeled spreader would require three horses and a rubber-tired spreader only two (See Table 2).

On the other hand, where only horses are used, where the haul is short, where gravel roads are not encountered, and where the annual use is limited, the addition of rubber tires to the conventional type manure spreader may not be justified. Even in such cases, however, it is well to consider the possibility of lowering tire costs per machine by arranging to use the same tires on two or more machines.

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[2]E. G. McKibben and J. B. Davidson. Life, service, and cost of service of pneumatic tractor tires. Bul. 382, Iowa Agr. Exp. Sta. 1939.

[3]J. B. Davidson. Life, service and cost of service of farm machinery. Bul. 92, Engineering Experiment Station, Iowa State College. 1929.

[4]E. L. Butz and O. G. Lloyd. The cost of using farm machinery in Indiana. Bul. 437, Agr. Exp. Sta., Purdue University. 1939.

Water-Application Efficiencies in Irrigation and Soil Conservation

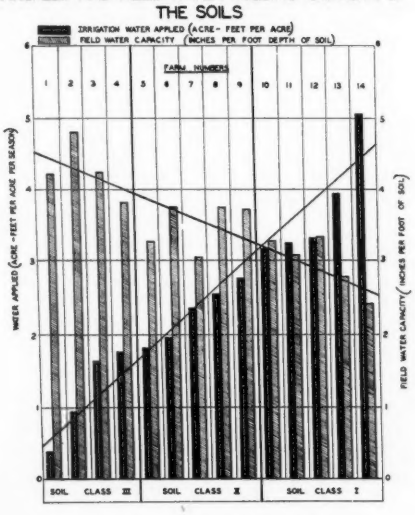
By O. W. Israelsen
FELLOW A.S.A.E.

THE maximum area of productive agricultural lands in arid regions is usually fixed by the amount of water required and the amount that can be made available for irrigation at reasonable cost, rather than by the area of arable land. This fact has resulted in acceptance of the idea that farm irrigation practices which conserve irrigation water should always be encouraged. It is well known that large areas of agricultural land in arid regions have been made nonproductive, or at least nonprofitable, because of a general rise in ground water and concentration of alkali. Deep percolation from the higher irrigated lands is the major factor contributing to the rise of ground water in the lower lands. Farm irrigation practices which result in excessive deep-percolation losses bring about low water-application efficiencies and leaching of nutrients from high irrigated lands, and also waterlogging and alkali concentration in low lands, and thus contribute to waste of water and depletion of soils.

In this paper a definition of the term "water-application efficiencies" is presented, a classification of irrigated lands with respect to relative elevation is suggested, and the results of some measurements of the amounts of water applied annually to different soils, together with the field-water capacities of these soils, are given. Typical preliminary measurements of soil moisture and distribution before and after irrigation on highland soils, lowland soils, and on soils of medium elevation are reported. A brief discussion of sources and disposal of water in farm soils is presented.

Contribution of the department of irrigation and drainage, Utah Agricultural Experiment Station, based on research conducted under cooperative agreement between the Bureau of Agricultural Engineering, U. S. Department of Agriculture and the Utah Station. The author is research professor of irrigation and drainage at the Utah Station. Authorized for publication in AGRICULTURAL ENGINEERING.

FIGURE 1
RELATION BETWEEN AMOUNTS OF WATER APPLIED ANNUALLY AND FIELD WATER HOLDING CAPACITY OF THE SOILS


IRRIGATION WATER APPLIED (ACRE-FEET PER ACRE)
FIELD WATER CAPACITY (INCHES PER FOOT DEPTH OF SOIL)
FARM NUMBERS
1 2 3 4 5 6 7 8 9 10 11 12 13 14
WATER APPLIED (ACRE-FEET PER ACRE PER SEASON)
FIELD WATER CAPACITY (INCHES PER FOOT OF SOIL)
SOIL CLASS III
SOIL CLASS II
SOIL CLASS I

The term "water-application efficiency" as recently defined by the Committee on Irrigation, American Society of Agricultural Engineers, is "the percentage of water applied that can be accounted for as soil-moisture increase in the soil occupied by the principal rooting system of the crop." Only a few measurements of water-application efficiencies have been made. The cost of measuring the amounts of water stored as soil moisture in the principal rooting zone of the farm soils is rather high with the best methods thus far developed and this probably accounts for the fact that so few measurements have been made.

Using the symbol W_s to represent the volume of irrigation water stored in the rooting zone under a given land area from an irrigation, W_f the volume delivered to the area irrigated, and E_a the water-application efficiency expressed as a percentage, it follows from the definition that

$$E_a = 100\, W_s/W_f \qquad [1]$$

(If we assume that the runoff losses are zero and that the amount of water consumed between the time of irrigation and soil sampling is negligible, then the water delivered to the area irrigated in one irrigation, W_f, must equal the sum of the water stored in the root zone soil W_s, plus the deep-percolation loss, D_f. Then $W_s = W_f - D_f$, and by substituting this in equation [1] there results

$$E_a = 100\ (1 - D_f/W_f) \qquad [1a]$$

It is evident from this equation and the assumptions stated above that, as the D_f decreases, E_a increases, and that when $D_f = 0$, the water-application efficiency will be a maximum.)

In the Utah studies of water-application efficiencies during 1937 and 1938, it has been found that surface runoff losses from the farms during July, August, and September are negligible. Therefore, for the purposes of this paper, the loss of water from the rooting zone by deep percolation during the time following irrigation until the soils are sampled for moisture is assumed to constitute the major loss.

DIFFICULTIES OF MEASURING WATER STORED IN SOIL

Measuring the volume of water stored in the soil at each irrigation is perplexing and costly. Since direct measurements of soil-moisture content by volume are impractical, it is necessary to obtain them by conversion from the direct measurements of moisture content by weight. To find the increase in moisture percentage from an irrigation, soil samples are collected before the water is applied and again one or two days after. Borings are made with a 2-in diameter post-hole type soil auger at six or more representative points in the field. (Experience thus far seems to indicate that the observed differences between the moisture content before irrigation and after irrigation with but six borings will be significant only for the most favorable soil conditions and for a considerable increase in moisture content.) A soil sample is taken to represent each foot of soil. The first foot, for instance, is represented by a soil sample taken

from a depth ranging from 3 to 9 in; the second foot by a sample from 15 to 21 in, and so on. About 250 grams of soil are used for each sample. Moisture determinations are made by drying the soils in an electric oven at a temperature of 105 to 110 C (degrees Centigrade). Average moisture percentages are computed for each foot depth of soil and average percentage after irrigation minus the average before is taken as the increase in soil moisture caused by the irrigation. Representative measurements of the apparent specific gravity of the soil are necessary to make the conversion from per cent by weight to per cent by volume. The depth of water stored as soil moisture in a given depth of soil is equal to the product obtained by multiplying the percentage moisture increase by the apparent specific gravity times the depth of soil considered. Two assumptions must be introduced, namely, (1) the depth of soil in which the soil moisture may be considered as "stored" and available to crops, and (2) the time period after irrigation at which further downward flow of water may be considered negligible, and therefore at which all of the moisture "stored" in the soil of the root zone will be available to the crops.

In view of the fact that soil moisture determinations at best must be restricted to the soil from a few borings per farm, because of the limitations in funds for research, and that at least two assumptions must be introduced, it is evident that a high degree of accuracy in the measurement of water-application efficiencies should not be expected.

SOURCES OF WATER CONSUMED BY CROPS

Crops growing in the root zone of the soil on each farm in irrigated regions may receive water from four sources, namely

Source	*Symbol*
Precipitation, or rain during growing season	r
Irrigation water, less surface runoff	w
Capillary water previously stored	m
Upward-flowing ground water	g

If the amount of upward-flowing ground water is relatively large, the amount of irrigation water required is correspondingly small.

Considering the crop year as the unit of time, and the soil volume of the principal rooting zone of the crop under a particular area, and using the symbols as above, the relation of water consumed, U, plus deep percolation losses, D_f, to water sources may be conveniently stated mathematically as follows:

$$U + D_f = w + r + m + g \qquad [2]$$

(Deep percolation losses from the principal rooting zone, D_f, do not occur simultaneously with upward flow, g. However, water may flow downward from the rooting zone at one time during the crop year and upward into this zone at another time.)

In many arid-region valleys, the precipitation (rainfall) r, during the growing season is small and may be neglected in this analysis. The quantity m is fixed largely by soil texture and depth and the farmer's irrigation practices. It is relatively small and may be neglected in so far as the following discussion is concerned. Applying these restrictions we may write

$$U + D_f = w + g \qquad [2a]$$

IRRIGATION STUDY OBJECTIVES AND SOIL CLASSES

During 1937 and 1938 the Utah Agricultural Experiment Station, in cooperation with the U. S. Bureau of Agricultural Engineering and the U. S. Works Progress Administration studied farm irrigation practices in detail on fourteen typical farms in Utah County.

The basic objective of the Utah studies of water-application efficiencies is to advance progress toward conservation of water and of soils. The more important specific objectives are to find the following:

1 The depth of water that can be stored in the root zone of typical soils, and thus to establish a guide for

FIGURE 2.

MOISTURE DISTRIBUTION BEFORE AND AFTER IRRIGATION IN THE CLASS I SOIL OF FARM NO. 14.

THE INCREASE IN MOISTURE CONTENT AT THE 3-FOOT DEPTH SUGGESTS LARGE DEEP PERCOLATION LOSSES INTO THE GRAVEL

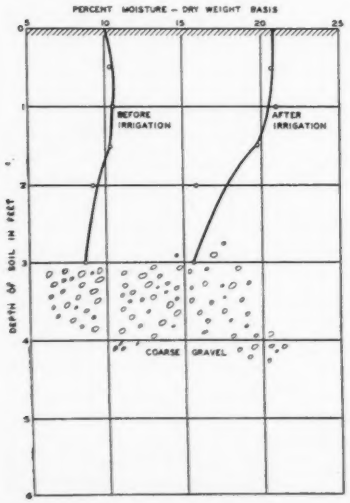


FIGURE 3.

MOISTURE DISTRIBUTION BEFORE AND AFTER IRRIGATION IN THE CLASS II SOIL OF FARM NO. 6.

THE LACK OF MOISTURE INCREASE AT THE 3-FOOT DEPTH SUGGESTS SMALL DEEP PERCOLATION LOSSES

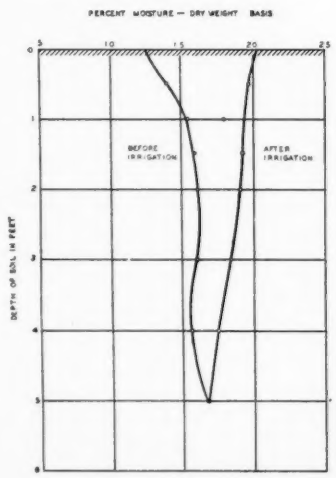
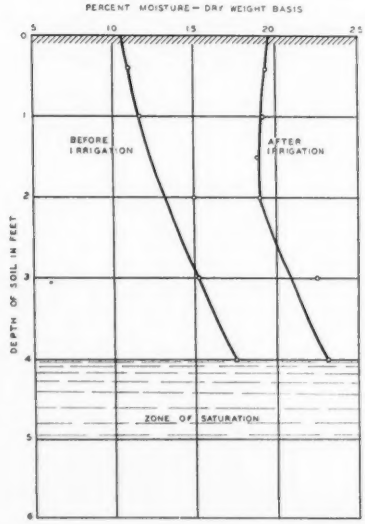


FIGURE 4.

MOISTURE DISTRIBUTION BEFORE AND AFTER IRRIGATION IN THE CLASS III SOIL OF FARM NO. 3.

THE INCREASE IN MOISTURE CONTENT AT THE 4-FOOT DEPTH SUGGEST LARGE DEEP PERCOLATION INTO THE GROUND WATER



farmers that will help them to avoid excessive applications and deep percolation losses.

2 Under ordinary farm irrigation practices, what proportion of the water delivered to the farmer at each irrigation is stored in the root zone of the soil.

3 The relation of water-application efficiencies to the methods of irrigation used by the farmer.

4 Methods of increasing water-application efficiencies at reasonable cost, and thus of conserving irrigation water and the fertility of irrigated soils.

The farms under observation represent three somewhat general soil classes in irrigated valleys, namely

I The soils of the valley highlands near the mountains. These soils are usually of shallow depth, coarse texture, and high permeability. The ground water in these soils, as a rule, is many feet below the land surface.

II The soils of the medium-elevation lands, which are largely loams and clay loams of satisfactory depth, average permeability, and with water-table depths ranging from 6 to 10 ft or more below the land surface.

III The soils of the low-lying valley-bottom lands which are usually clay soils of fine texture and low permeability, with the water table ranging from less than 1 to 3 ft or more in depth.

In the Utah water-application efficiency research work Class I soils have the lowest field-water capacity, Class II medium field capacity, and Class III maximum field capacity (Fig. 1).

WATER SOURCES IN RELATION TO APPLICATION EFFICIENCIES

The quantities D_t, w, and g of equation [2a] differ appreciably, even though the consumptive use U for a particular crop in a given valley may be practically the same for each of the three soil classes. For convenience, we may write [2a] in the form

$$U = (w + g) - D_t \qquad [2b]$$

In class I soils there is no upward flow of soil water to supply crops and therefore, in these soils

$$U = w - D_t \qquad [2c]$$

Class I soils, as a rule, are highly productive if a readily available supply of moisture is maintained. In order to irrigate them by furrow and flooding methods the percolation losses, D_t, are relatively large, and therefore w must be greater than U. Low water-application efficiencies result. The moisture distribution curve for Farm No. 14, having class I soils, presented in Fig. 2, shows that excessive losses occur from deep percolation.

Alkali troubles are rarely, if ever, encountered in these soils. The productivity of Class I soils in Utah valleys has thus far been relatively well sustained. This seems to indicate that deep-percolation losses, which cause low water-application efficiencies, do not cause rapid depletion of fertility by leaching of plant nutrients from the soils. However, excessive deep-percolation losses no doubt carry away in solution appreciable amounts of nitrates and other soluble nutrients, and if continued for many years, may cause serious depletion of soil productivity.

In Class II soils, the quantities D_t and g are usually low. Under the most careful irrigation practices and with favorable natural drainage, deep-percolation losses may be compensated by upward flow and thus make the sum of D_t plus g negligible, in which case we may write (remembering the restrictions previously stated for r and m) the equation

$$U = w \qquad [2d]$$

The 1938 moisture distribution curves on Utah County Farm No. 6, having Class II soils, given in Fig. 3, typifies the condition illustrated by equation [2d], that is, that nearly all of the irrigation water is consumptively used.

In Class III soils, without adequate drainage, low water-application efficiencies and resulting large deep-percolation losses do not contribute to loss of water by deep percolation, but rather to loss of soil productivity due to the rise of the water table and consequent acceleration of upward water flow and alkali concentration. Water losses from excessive evaporation may be significant. These soils rarely have adequate natural drainage, but if properly drained by artificial means, then low values of E_a and resulting high values of D_t, continued for a few years, will contribute to leaching of alkali and to conservation of the soil productivity. The 1938 moisture distribution curve for Utah County Farm No. 3, having Class III soils, presented in Fig. 4, typifies large values of D_t and low E_a. In Class III lands, the quantity g of equation [2b] is usually much larger than D_t and it also may be larger than w.

The fact that w is large for Class I soils, medium for Class II soils, and low for Class III soils in Utah County is shown clearly in Fig. 1, based on 1937 and 1938 irrigation practice. Moreover, the amounts of w for Class III soils in all probability are lower than U, thus showing, from equation [2b] that the quantity g must have been appreciable.

CONCLUSIONS

The observed results of irrigation practices in Utah valleys, together with analyses and preliminary data presented, seem to justify the following tentative conclusions:

1 Low water-application efficiencies and resulting deep-percolation losses (or lack of conservation of irrigation water) on Class I soils may not cause rapid depletion of soil fertility. However, such irrigation practices on Class I soils cause decrease in productivity of Class III soils in the same valleys by contributing to rise of the ground water and concentration of alkali.

2 In Class I soils the amount of water consumed is smaller than the amount of irrigation water applied; in Class II soils the amount consumed is more nearly equal to the amount applied, and in Class III soils not adequately drained the amount consumed usually exceeds the amount applied.

3 Irrigators may contribute to water conservation by increasing water-application efficiencies on all three classes of soils, and also thus contribute especially to the conservation of Class III soils by prevention of water logging and alkali concentration.

4 By decreasing water-application efficiencies for periods of a few years, and thus causing large deep percolation losses in artificially drained Class III soils, irrigators may contribute to the conservation of these soils and thus justify water losses.

5 Measurements of water-application efficiencies by public research agencies merit more attention than they have been given thus far.

ACKNOWLEDGMENTS: The author acknowledges with gratitude the assistance of Messers. Wayne D. Criddle and Dean K. Fuhriman in the preparation of data and charts for this paper, and also the helpful criticism of the manuscript by Director R. H. Walker and Dean George D. Clyde.

Fresh Air in Farm Buildings

By H. N. Stapleton
MEMBER A.S.A.E.

INTO this discussion, I want to put the whole subject of farm building ventilation because it definitely needs overhauling. It probably even needs complete rebuilding. We seem to have reached a condition where we need to have either an auction or a good fire. New tools and new methods are available, but we seem to have a perverse fixation concerning the "something for nothing" gravity flue.

To illustrate this point, let's consider dairy stable ventilation. The arithmetic of the problem looks like this:

1 Moisture to be removed every 24 hr: 11 to 18 lb per cow, 16 to 22 cows equals 1 bbl, 1/16 in over the entire stable floor.

2 Air purity (CO_2 concentration): Approximately 60 cu ft per cow per minute required for adequate dilution of used air (For 15 parts CO_2 in 10,000).

3 Odors which would contaminate milk must be removed.

4 Heat production to maintain temperature approximately constant at 3000 btu per hour per cow, equal to 12½ sq ft cast iron radiation, equals 0.9 kwh.

Usable heat is all we have with which to ventilate. The more heat, the more air we can utilize. Kelley's studies in Wisconsin showed stable temperatures of 45 to 55 F most desirable. In cold climates insulation is necessary if there is to be any degree of stable temperature control. Harrington recommends three one-inch thicknesses of boards, or their equivalent, for western Massachusetts, while he specifies two or their equivalent for the eastern part of the state. In Vermont, when we want to make sure, we just fill the stable wall with shavings (with waterproof paper inside and outside of the fill of course) and then add storm sash if the windows frost up. The storm sash may or may not be necessary, depending on the wall construction and the exposure of the building to winds.

With the walls and ceiling well enough insulated that there will be some heat to remove by ventilation, we then need some scheme for bringing air into the stable and taking it out again. This ventilation scheme is required to maintain stable temperature (within reasonable limits), maintain air purity, carry off moisture and odors, and do it uniformly throughout the stable without drafts. That's a fairly large order and it is not much wonder that most ventilating systems are somewhat short of perfection.

Intakes of about 60 sq in cross section fit most barn wall framing pretty well, with the opening 5x12 in or equivalent. Distributed along the walls, one for each 3½ cows, this begins the solution of uniform distribution. Any make of intake can be used. "Cornell" intakes can be made at about $2.50 each. Anti-backdraft dampers can be used in them, or omitted if the barn is somewhat protected from winds.

If gravity outtake flues are used these things should be considered: The flues should be kept large, and square or round to minimize their condenser action on the moist air and to save material. As commonly installed, they are not well insulated. Ice forms, choking the system and playing hob in general with both the building and the stable. Any change in wind direction or velocity or in outdoor temperature affects the system exactly opposite to the adjustment necessary to compensate for the change in wind velocity or outdoor temperature. The initial cost of a properly designed and built outtake flue system is high.

It does not profane the attainments of Rutherford and King to say that, had exhaust fans and rural electric service been available when this dairy stable ventilation problem needed solution, they would not have looked twice at a haymow flue. They took what was at hand and made something of it that worked, when properly installed. But if we farm building ventilation people are going to keep on worshipping the glories of Rutherford and King, it will be a little while before there will be any progress in farm ventilation. Rather, shouldn't we use the same ingenuity as Rutherford and King, take the results of 50 years of progress, and adapt them to this ventilation problem? I think so.

I referred to the high cost of haymow outtake flues. This is what I mean. Installed in the wall, the cost of a fan of equal capacity, and 10 to 15 years of operation will equal the initial cost of the gravity flue. By operation, I mean that the fan runs continuously from October through April of each year. A thermostat of the on-off type is out, both because it is expensive and it provides a ventilating system comparable in operation to a car that has 0 and 40 miles per hour for operating speeds. A variable-speed fan or at least a two-speed fan will give necessary control of air movement, or a damper can be provided in the riser to choke delivery during extremely cold weather.

As a profitable farm use of electricity, fan ventilation of farm buildings measures up nicely. It is an inexpensive method of doing a job well. Fans are reasonable in price and because one kilowatt hour will move from one-half to one and one-half million cubic feet of air, free delivery, fans provide the best way to move air. The motors are usually small, so that wiring isn't much of a problem and once installed, the outfit is practically trouble-free.

The fan for dairy stable ventilation that I have been recommending for 35 to 50-cow barns is a two-blade propeller type with a two-speed, dual-voltage, ball-bearing motor of ⅛ hp. The input wattage is 168 and the free delivery rating 3020 cfm. This figures 1,080,000 cu ft per kilowatt hour and the fan and two-speed switch sell in Vermont for $67. Its energy use per month by calculation and by check meter is 121 to 125 kwh depending on whether the month has 30 or 31 days.

As a farm use of electricity; from the standpoint of the farmer it is a job well done for $2.50 to $3.50 a month, and from the standpoint of the electric company it is an appliance of 168 watts demand, and the monthly use of energy of an electric range.

As we think of this new tool for barn ventilation let's think of its application in other farm building ventilation as well. That's why I said in the beginning that I think the whole subject needs overhauling. We've got something we can use—why not use it? Rutherford and King had a haymow flue emulating the farmhouse chimney but we have something vastly better that can be controlled by a push-button or with relays, if we will only wake up and do something with it. Let's apply ourselves and make the most of 50 years of progressive farm building ventilation.

Presented before a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at Farmingdale, L. I., N. Y., September 14, 1939. The author is agricultural engineer with the Green Mountain Power Co.

Laboratory Tests of Concretes and Mortars Exposed to Weak Acids

By Dalton G. Miller, Philip W. Manson, and Charles F. Rogers
FELLOW A.S.A.E. MEMBER A.S.A.E.

THE TEST method described in this paper was devised primarily to facilitate laboratory studies of the durability of portland cement mortars and concretes exposed in farm silos to the corrosive action of silage. The method and equipment seem to be well adapted to the study of the corrosive action of soluble materials in general on products of various types.

It is generally assumed that the common acids of corn silage are volatile acids consisting very largely of acetic acid, and non-volatile acids generally calculated as lactic acid, although not necessarily wholly lactic acid. The degree of acidity of good silage, expressed in pH values, will range between pH 3.40 for the most acid and pH 3.90 for the least acid. These values indicate very mild acidity, about that of unsweetened cherries or apricots, but as acids they will react with the cement until neutralized or until the cement is gone. Solutions of acetic acid 0.1*N* (normal), lactic acid 0.1*N* and the two acids combined in approximately equal parts to give 0.1*N* were used in the tests but results obtained only with the mixture are reported in this paper. The acidity of this mixture is pH 2.5 at room temperature.

Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers at St. Paul, Minn., June 20, 1939. University of Minnesota Paper No. 1718, Scientific Journal Series. The authors are, respectively, senior drainage engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture; instructor in agricultural engineering, Agricultural Experiment Station, University of Minnesota, and Minnesota State Department of Conservation; and assistant biochemist, division of biochemistry, Agricultural Experiment Station, University of Minnesota.

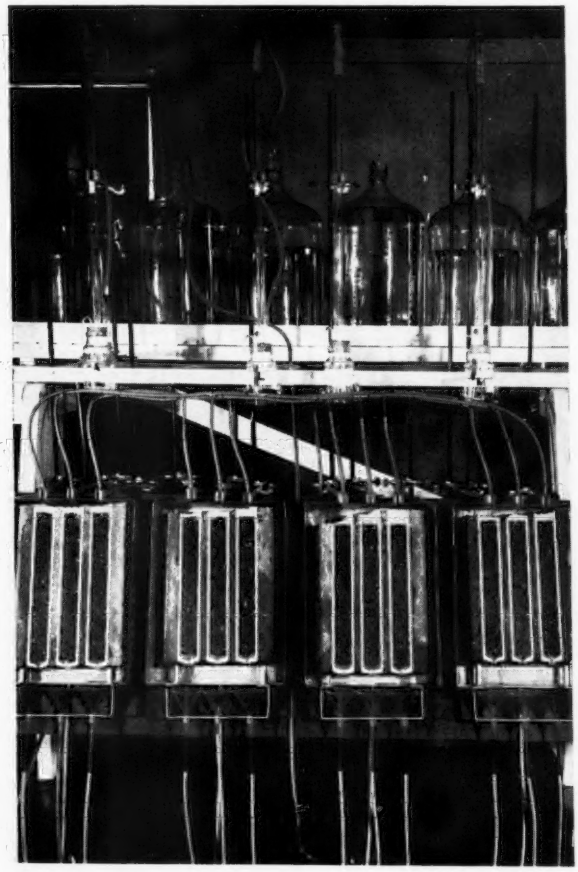


FIG. 1 APPARATUS FOR LABORATORY TESTS OF CONCRETES AND MORTARS EXPOSED TO WEAK ACIDS

The general scheme of the test is to flow acid solutions across flat slabs of concrete set nearly vertical (17-deg departure). Halves of concrete silo staves have been used in some cases, while in other cases special laboratory-made bars of standard Ottawa sand were used. The bars measured 2½x3x15 in and were cast with recessed panels for the acid flow. The flow of acids on the specimens is confined between paraffin dykes so spaced that the area of contact is 14 in long and 1½ in wide. The rate of flow through a channel is fixed at 2 liters per 24 hr. Each 24 hr the channels are cleaned of loosened material by brushing with a 1-in flat brush of steel wire. The brushings are caught in 5-in funnels lined with filter paper, oven dried, and weighed. The brushing is done under a small water jet and ordinarily about 400 cc of water is caught with the material released by each channel.

The solutions are applied to the specimens at the upper ends of the channels by a drip method using glass capillary tubes. A convenient head for the setup is about 13 in, and by experiment it was found that 1-in lengths of capillary tubing with an opening of 0.009 in delivered the desired quantity. Only minor adjustments of head are necessary to effect the 24-hr, 2-liter flow. Adjustments of head within the necessary limits are made by either raising or lowering the tip, or the glass standpipe (Figs. 1 and 2). It is believed the data of Tables 1 and 2 show highly satisfactory test results as indicated by the quantity of material released by each brushing.

The graphs of Figs. 3 and 4 are plotted from data obtained by flowing for 50 days 0.1*N* solutions of a mixture of acetic and lactic acids across the faces of halves of three 2½x10x30-in concrete silo staves. The transverse strengths of these staves at 28 days were 102, 124, and 146 lb per inch of width (24-in span and load applied at midpoint) and the moduli of rupture 590, 715, and 840 lb, respectively. The three staves which were made at the same plant, differed only in the richness of the mix, with a slightly higher water-cement ratio for the lean mix in order to maintain the required consistency. The water-cement ratio for dry-tamped staves of the richer mixes is ordinarily about 3½ gal per sack of cement. The stave with a modulus of rupture of 590 lb was from a lot made 12 staves per sack of cement, while the staves with moduli of rupture of 715 and 840 lb were from lots made 9 and 7 staves, respectively, per sack of cement. The accumulated losses of ma-

terial at 10-day intervals are shown in Fig. 3, while loss ratios for each 10-day period are shown for the three staves in Fig. 4.

The graphs of Fig. 5 show the relative resistance to a 0.1*N* mixture of acetic and lactic acids of 26 silo staves as indicated by the accumulated quantity of material loosened by 30 daily brushings. Eleven staves were made at plant A, thirteen at plant B, and two at plant C. The plant A and plant B curves are similar. The losses were greater for the staves from plants B and C than for those from plant A, when considered on a strength basis. The behavior of the staves from plant C is explained because the aggregate used at plant C carried 3½ per cent shale while that used at the other two plants carried less than 0.5 per cent. The differences in losses displayed by the staves from plants A and B are not so readily explained and will not be considered in this paper. It is obvious that the lower ends of the graphs of Fig. 5 are constructed from meager data because few points were available for staves with a modulus of rupture in excess of 850 lb per square inch. (Transverse strength 148 lb per in of width.) It is evident, however, that the break in the direction of the curves must come somewhere below a modulus of rupture of 1000 lb; therefore, these graphs as drawn cannot be much in error.

In the manufacture of dry-tamped staves, as generally made, it is necessary to use non-plastic mixes because the forms are stripped immediately after tamping, and undue deformation follows when the consistency of the mix approaches a plastic state. Just how much deformation is permissible for commercial staves is a matter upon which manufacturers are not in complete agreement, but the edges can not be greatly out of line without causing trouble when the silo is erected. Some manufacturers consider that a stave is not satisfactory if as much as 1/32 in out of line, measured along either 30-in edge. It is obvious that the tendency is to use consistencies entirely too dry.

The effect of consistency of the mix on the acid resistance of dry-tamped staves is illustrated in Fig. 6. This figure is based on tests of only six staves from two plants,

TABLE 1. TWENTY-DAY RECORD OF BRUSHINGS FROM TEN SILO STAVES MADE AT A COMMERCIAL PLANT

(Note Consistent Daily Losses for Individual Specimens)

Duration of exposure, days	Material lost from concrete staves, in grams									
	Transverse strengths, pounds per inch of width									
	213	142	144	133	134	129	132	96	90	92
	Moduli of rupture, pounds per square inch									
	1227	818	829	766	772	743	760	553	518	530
1	0.9	2.2	2.2	3.8	4.2	3.8	4.9	4.1	6.5	7.1
2	2.1	2.8	3.1	3.3	2.8	3.5	2.8	4.8	4.6	4.9
3	2.4	2.8	2.8	3.2	2.7	3.5	3.2	4.5	4.6	4.3
4	2.8	3.0	3.4	3.1	3.1	3.5	3.9	5.3	4.1	5.4
5	2.2	2.4	2.9	2.4	1.0	2.6	3.5	4.2	4.6	5.0
6	2.8	2.3	2.5	2.8	2.4	2.8	3.5	5.0	5.8	5.9
7	2.5	2.0	1.9	2.4	2.1	2.7	2.9	4.5	5.1	5.9
8	2.1	2.2	2.5	2.2	2.7	2.2	2.9	5.3	5.4	7.4
9	2.7	2.4	3.4	2.9	2.7	2.4	3.2	6.7	6.6	7.1
10	2.1	2.1	2.1	2.6	2.4	3.1	2.5	4.9	6.6	5.9
11	2.4	2.1	2.4	2.4	3.6	3.4	3.0	5.7	6.3	6.5
12	1.9	2.1	2.6	2.3	2.2	2.4	2.4	5.7	7.4	7.5
13	1.8	1.5	2.3	1.8	3.6	2.3	3.1	5.1	3.9	7.8
14	2.2	2.0	2.9	2.1	3.9	3.6	2.8	8.2	7.3	7.8
15	2.3	1.7	2.6	2.6	3.6	2.9	3.5	5.0	5.7	10.0
16	1.8	2.2	2.2	2.4	1.1	2.4	3.1	5.6	7.4	7.7
17	2.5	2.4	2.9	3.4	2.6	4.5	3.2	8.1	7.9	6.6
18	1.5	1.7	3.0	3.0	2.9	3.0	2.5	6.7	7.9	4.6
19	2.3	2.1	1.8	2.4	4.5	4.1	3.8	6.3	5.7	8.0
20	1.8	1.6	2.5	2.1	3.6	3.0	3.9	6.5	7.0	9.6
Totals	43.1	43.6	52.0	53.2	57.7	61.7	64.6	112.2	120.4	135.0
Daily average	2.2	2.2	2.6	2.7	2.9	3.1	3.2	5.6	6.0	6.7
Loss ratios	1.00	1.01	1.21	1.23	1.34	1.43	1.50	2.60	2.79	3.13

TABLE 2. TWENTY-DAY RECORD OF BRUSHINGS FROM ELEVEN BARS OF STANDARD OTTAWA SAND MORTAR MADE OF DIFFERENT CEMENTS

(Note Consistent Daily Losses for Individual Specimens)

Duration of exposure, days	Material lost from bars of standard Ottawa sand, in grams									
	Cement laboratory numbers									
	740	725	739	737	736*	738*	732	735	728	729	727
1	1.4	1.5	1.5	1.5	2.5	2.1	2.9	4.1	3.1	6.1	6.3
2	3.4	4.4	4.2	5.5	6.2	6.1	6.9	7.4	7.5	8.0	8.0
3	4.1	5.9	5.8	4.7	5.1	6.1	6.1	5.8	6.2	7.3	7.4
4	4.8	6.2	5.6	6.0	6.1	5.6	6.7	7.0	7.1	7.8	7.6
5	5.6	6.5	6.4	7.1	7.1	6.5	7.1	6.9	7.6	8.0	8.7
6	5.4	5.7	6.5	6.5	5.9	6.7	6.4	6.5	7.2	7.8	6.6
7	5.1	6.7	6.1	7.0	6.9	6.1	7.2	6.9	7.1	8.0	9.7
8	6.3	5.5	7.2	7.9	7.3	7.6	6.8	6.7	7.1	8.0	8.1
9	6.1	7.6	7.0	7.0	6.9	6.6	7.1	7.7	7.9	8.3	8.9
10	6.4	8 2	7.5	7.9	8.3	8.1	8.1	8.1	9.0	9.2	10.3
11	6.9	6.0	7.6	7.6	7.0	7.1	7.8	7.2	7.2	8.2	7.5
12	6.5	7.6	6.8	7.6	6.7	7.4	7.0	7.3	8.3	8.6	8.6
13	4.7	7 2	6.2	6.3	8.0	6.2	8.3	7.3	8.3	7.9	8.7
14	5.3	7.9	8.2	7.3	8.1	7.8	7.7	7.3	9.7	9.3	9.9
15	4.7	6.3	6.8	6.5	5.7	6.1	6.0	6.0	6.2	6.7	7.1
16	5.1	6.9	7.0	7.0	7.3	7.6	7.3	7.8	7.7	9.1	8.5
17	5.1	6.1	7.7	5.2	6.4	6.8	6.1	6.4	6.7	7.6	7.8
18	5.0	6.4	7.5	8.3	6.6	8.1	7.2	7.1	7.3	8.2	7.9
19	5.2	6 2	6.6	7.3	7.3	6.8	6.8	6.4	7.7	7.7	8.3
20	4.2	6.3	7.3	6.4	7.1	7.1	7.6	7.7	8.8	9.3	8.5
Totals	101.3	125.1	129.5	130.6	132.5	132.5	137.1	137.6	147.7	161.1	164.4
Daily average	5.1	6.3	6.5	6.5	6.6	6.6	6.9	6.9	7.4	8.1	8.2
Loss ratios	1.00	1.23	1.28	1.29	1.31	1.31	1.35	1.36	1.46	1.59	1.62

*High early strength.

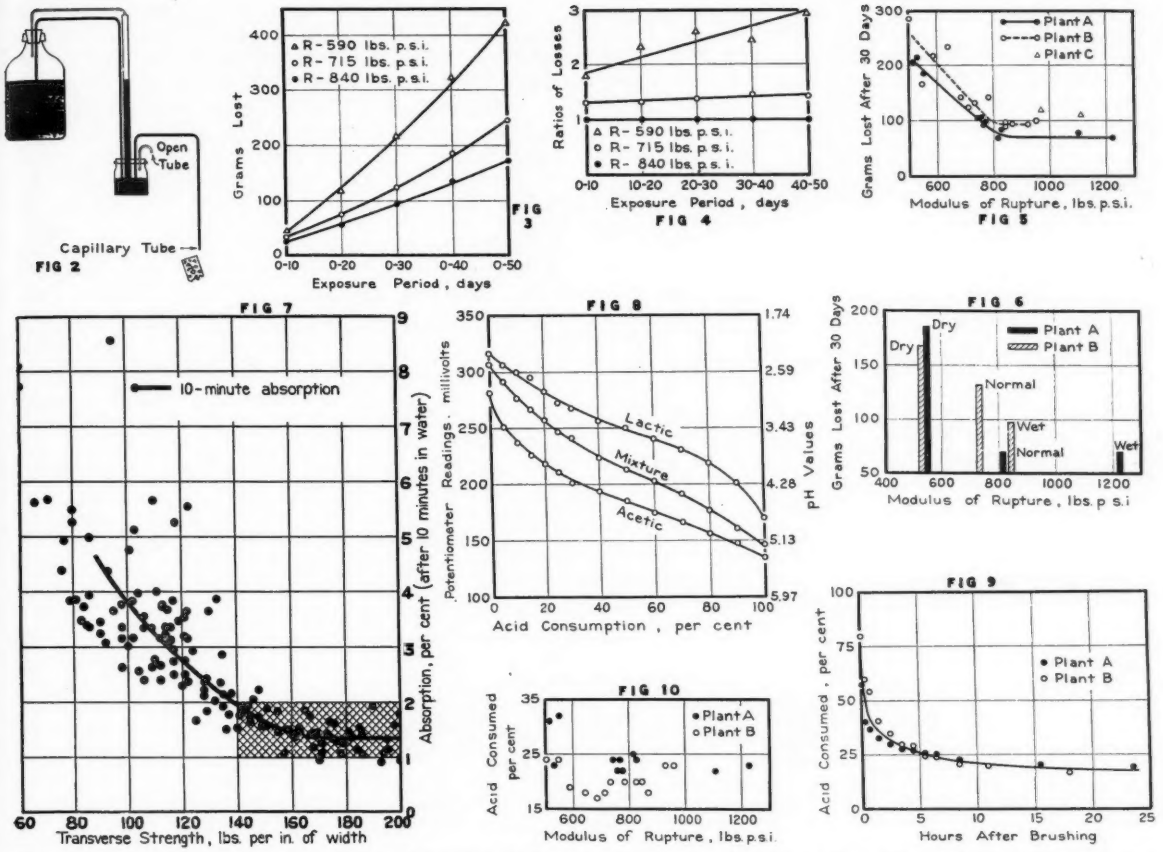


Fig. 2 Side elevation showing the essentials of one unit of Fig. 1 for controlling the rate of flow. Fig. 3 Material lost from three concrete staves of different strengths. Fig. 4 Ratios of losses of material from the three staves of Fig. 3. Fig. 5 Material lost from 26 concrete staves of widely different strengths. Note that losses of material did not increase for moduli of rupture above 850 lb per sq in. Fig. 6 Relation between quantity of material lost after 30 brushings of concrete staves of three consistencies from two plants. Fig. 7 Relation between the transverse strength of dry-tamped silo staves and 10-min absorption following oven-drying at a temperature of 240 F. Fig. 8 Experimental curves showing relation between the consumption of acid as used in the tests and potentiometer readings. Fig. 9 Effect of brushing on acid consumption. Each point is the average for four staves. Fig. 10 Relation between acid consumption and the strength of concrete staves. It is not apparent that there is any correlation between acid consumption and modulus of rupture unless it is indicated for the weakest concrete

but even so the results appear to have some significance. It will be noted that the very dry staves from each of the two plants were the weakest and were least resistant to acid. The wetter mixed staves were strongest at each plant, but the wet stave from plant A, although 50 per cent stronger, was no more acid resistant than was its companion stave made of the consistency regularly used at the plant. This stave was made so wet it could not be classed as a commercial product. The other five staves of Fig. 6 met commercial requirements with respect to straightness. The staves from each plant had the same aggregate grading and same richness of mix, the only variable being the quantity of mixing water.

Present specifications for concrete silo staves require that the 28-day ultimate transverse strength must average not less than 90 lb, with no test falling below 75 lb for each inch of width of the stave. The calculated moduli of rupture for these transverse strengths are, respectively, 432 and 518 lb per sq in. Results of the tests reported in this paper clearly show that staves which somewhat exceed these strength requirements are low in acid resistance as compared with that displayed by staves with transverse strengths of 140 lb per inch of width. It has been found (Fig. 7) that the regain of water by dry-tamped concrete silo staves after soaking for ten minutes, following oven-drying at 240 F (degrees Fahrenheit), progressively decreased as the transverse strengths increased to 140 lb per in of width, while the gain was about constant between 1 and 2 per cent for staves testing stronger than 140 lb. This transverse strength represents a modulus of rupture of about 800 lb per sq in and apparently marks a critical change in density of the staves. It so happens that, in the plant processes ordinarily used in making concrete silo staves, it is difficult to manufacture staves with a modulus of rupture of 800 lb per sq in, except by the use of rich mixes with a cement-void ratio approaching 1.00. In the tests as conducted when this ratio decreased, the resistance of the staves to the acids became less. Tests have been made on only a few staves with a cement-void ratio in excess of 1.00, but such as have been made do not indicate greatly increased resistance to acid corrosion.

It is not unduly difficult to manufacture commercial concrete silo staves which test 140 lb, or more, per inch of width, providing not more than 7 or 8 staves are made per sack of cement, using a reasonably well-graded aggregate. About 800 staves are required for a 14x40-ft silo. When made at the rate of 8 staves per sack, 100 sacks of cement are used in their manufacture. When made at the rate of 11

staves per sack, 73 sacks of cement are used. Assuming the cost of cement at 55 cents per sack, the saving on 27 sacks amount to $14.85. The complete cost of a 14x40-ft concrete stave silo runs between $600 and $800; therefore, a difference in cost of $14.85 is less than 2½ per cent. The acid tests as applied in the laboratory have shown about three times the resistance of 140-lb staves as compared with staves testing 90 to 100 lb per inch of width.

Keeping in mind that some loss must always follow exposure of concrete to acid under the routine of the test herein described, a study of Figs. 5 and 6 will show that the possibilities of greatly reducing the losses from the more resistant type of specimen appear to be extremely remote unless, by some means, the cement itself can be made more resistant.

The degree of acidity was determined for many samples of the solutions flowing over the surfaces of the specimens, in order to study the possible correlation of the quantity of acid consumed with known characteristics of the concrete or mortar. To facilitate this phase of the studies, the experimental curves of Fig. 8 were constructed. Fig. 9 shows the average percentage of acid consumed at various time intervals as determined in off-flow samples of a 0.1*N* solution of acetic and lactic acids from 8 silo staves. Each point is the average of 4 staves from one of two plants. The moduli of rupture of the staves ranged between 530 and 840 lb per sq in for transverse strengths between 92 and 146 lb. The acid consumption dropped rapidly from 70 per cent for the first 15 min to about 25 per cent at 5 hr, and thereafter the change of rate was slow.

Reduction in rate and use was probably the result of accumulation of inert residue from the chemical action of these acids on the constituents of the cements. This layer was removed when the channel was brushed and the rate of chemical action increased for a time. The amount of acid consumed during the first 12 hr period was slightly in excess of 60 per cent of the total for 24 hr, indicating that brushing twice daily instead of once would increase the quantity of loosened material something like 20 per cent. Brushing at hourly intervals might increase the loosened material as much as 100 per cent per day.

From study of Fig. 10 it appears that consumption of acid has no particular relation to the quality of the concrete unless greater acid consumption is indicated in extremely low-grade concrete. As this test was applied, it would seem that the constituents of the cement available for the acid requirements were about equal in all the specimens, although a greater quantity of aggregate was loosened by deeper penetration of acid into the more permeable lean-mixed staves than was loosened in the rich-mixed and relatively impermeable staves as shown in Figs. 3, 4, and 5.

The weaker specimens yielded about three times as much material as did the stronger ones. Stating it in another way, the depth of corrosion in the weaker specimens was about three times that of the stronger ones. A practical inference of this fact is that the low-quality specimens could not last more than one-third as long as those of high quality under conditions of exposure represented by these tests.

Nine standard portland cements and two high-early-strength cements were subjected to the flow test for resistance to a 0.1*N* solution of acetic and lactic acids by use of the specially made 2½x3x15-in bars. The order of listing of the cements in Table 2 is the same as the loss ratios after exposure for twenty days, taking as unity the quantity lost from the most resistant of the eleven specimens. The greatest difference in resistance of the nine standard portland cements was as 1.0 is to 1.6.

The two high-early-strength cements included in the group gave results almost identical with those of their companion standard portlands. In Table 2 the standard portlands are numbered 735 and 737, while the companion high-early-strength cements are numbered 736 and 738, respectively.

Applying Integral Horsepower Electric Motors to Farm Equipment

IT HAS been generally assumed that there is little farm equipment available that has been designed, manufactured, advertised, and sold specifically for operation with integral horsepower electric motors.

With this in mind our committee selected certain farm equipment which it knew was adapted to electric motor drive. Letters were sent to the manufacturers asking them to list the models which come equipped with an electric motor as a part of the unit. It was further emphasized that if no motor was included, the farmer should be able to install a permanent motor or use a portable power unit without necessitating any changes in the design of the machine. The limit placed on electric motors to operate the equipment was set at 10 hp.

The committee decided to investigate ensilage cutters, grain blowers, corn shellers, feed grinders, feed mixers, water systems, concrete mixers, hay hoists, milking machines, dairy refrigerators, and wood saws. Information as to models and electric motor sizes as submitted by the various manufacturers of this farm equipment was tabulated. The survey revealed a much larger number of machines designed for electric motor operation of from 1 to 10 hp inclusive, than had been anticipated.

A contribution of the A.S.A.E. Committee on applying Integral Horsepower Electric Motors to Farm Equipment—F. H. Hamlin, F. M. Mason, B. D. Moses, L. C. Prickett, L. E. Shirley, and J. P. Schaenzer (chairman). Received June 1939.

For the eleven farm machines investigated, 120 manufacturers reported that they had developed 596 models designed for electric-motor drive. Of these, 334 were water systems, making up more than one-half of the total. The other ten ranged from three grain blowers, the lowest number, to 73 for ensilage cutters, the highest. Statistics for all machines follow:

Farm machine	Number of manufacturers reporting	Number of models designed for electric-motor drive
Ensilage cutter	24	73
Grain blower	2	3
Corn sheller	13	27
Feed grinder (Hammer)	15	22
Feed grinder (Burr)	8	30
Feed mixer	5	12
Water system	20	334
Concrete mixer	3	6
Hay hoist	5	8
Milking machine	4	10
Dairy refrigerator	4	8
Wood saw	17	63
Totals	120	596

Lists of the manufacturers of the farm machines investigated, including names of models and power requirements of each, have been prepared by the committee members.

Water Rights for Irrigation in Humid Areas

By Wells A. Hutchins

THE "humid areas" with which this paper deals are those in the eastern part of the United States, that is, that portion which lies east of the tier of states extending from North Dakota to Texas on the one-hundredth meridian. So-called western water law, on the other hand, applies to the 17 western states, including those on the one-hundredth meridian, where the climatic and landed conditions are markedly different from those in the East.

The volume of laws affecting rights to the use of water in the eastern states is meager, in contrast with that in the West. It is based principally upon court decisions, in which the courts have been guided largely by the principles of the common law of England, adopted with such modifications as appeared necessary to the circumstances of the controversies.

The riparian doctrine applies to the use of water flowing in surface streams in the East. This rule, in its strict form, originally meant that each owner of land bordering upon a stream had the right to have the stream flow in its natural channel, undiminished in quantity, and unpolluted in quality. A strict enforcement obviously would prevent any riparian owner from consuming any of the water, so the rule has been modified, both in England and in this country, to allow the riparian owners to make use of the water.

GENERAL CONCEPTS OF RIPARIAN RIGHTS

Without going into all the refinements it may be stated that, in general, the riparian right entitles the landowner to all the water he needs for drinking and other household purposes, and for the watering of his livestock. For those purposes, if absolutely necessary, he may exhaust the entire stream; but there is a question as to whether he can exhaust the stream for the watering of large herds of stock, if there are riparian owners downstream who need that water for strictly domestic purposes. Furthermore, while irrigation is recognized as a use to which the riparian owner can put water under his riparian right, he cannot exhaust the stream for irrigation purposes, but may use only an equitable share of the stream flow; that is, such use on his part is limited to a reasonable use of the water on his riparian land, in relation to the reasonable requirements of other riparian owners.

Ground waters—that is, waters in the strata under the surface of the earth—are subject to another set of legal rules. Where such waters are shown to be flowing in definite underground channels, or where they constitute the underflow of surface streams, rights to their use are governed by the law of surface watercourses, which in the East is the riparian doctrine. But where they are what the courts have called percolating waters, which is the case in most controversies, they belong to the owner of the land under which they happen to occur, subject in some states to restrictions upon use as noted below. These percolating waters are waters seeping through the interstices of the soil, moving by gravity in whatever direction and at whatever rate the geological structure allows. While criticisms have been directed at the legal classifications made in some court decisions, as being out of line with the physical situations involved, nevertheless the distinction between definite underground streams and diffused percolating waters is an important principle of ground-water law and must be recognized in any discussion of that subject.

Percolating ground waters are held by the courts of some eastern states to be the absolute property of the landowner. Where this is the rule, any landowner may make unlimited use of all the water he can pump from his land, and can use it on that land or sell it to others for use at distant points, at his pleasure, regardless of the fact that his pumping may deplete the supply otherwise available for the owners of other lands overlying the same subterranean basin. In other eastern states, the owner of overlying land owns the percolating ground water, but is limited by court decisions to a reasonable use in connection with the overlying land. This means that if the owners of other lands overlying the same ground-water supply wish to make use of the water, no one owner can export the water to distant points if the other landowners are thereby deprived of their own coequal right to use the water for reasonable purposes on their overlying land. Each overlying landowner, in other words, is limited to a reasonable use in relation to the same use by all the others. This right is very similar to the right of an owner of land riparian to a surface stream to use the water for irrigation.

Turning now to the western states, in which the natural precipitation is so generally inadequate, and in many parts of which artificial irrigation is absolutely essential to successful agriculture, it is found that the legislatures and courts have developed new principles governing rights to the use of water. They have established the doctrine of prior appropriation, and have applied it to surface streams in all the western states and to ground waters in some states. The appropriative right is a statutory right; the courts have upheld the principle and have rendered many decisions which interpret the statutes in their application to controversies of widely varying circumstances. Water may be appropriated for irrigation, domestic use, power, manufacturing, or other beneficial uses.

DOCTRINE OF PRIOR APPROPRIATION DEVELOPED IN WEST

The right to the use of water acquired by prior appropriation is an exclusive right to make beneficial use of the quantity appropriated, and the use may be made in connection with land far removed from the stream as well as on land contiguous to it. The earliest appropriation on a stream has the first right, and every appropriation is subordinate or junior to those antedating it, and is superior or senior to those made at later dates. Each appropriation carries the right to a specific quantity of water, measured in cubic feet per second in case of direct flow or in acre-feet in case of storage. Therefore, it is only the early priorities that are entitled to divert the water of a stream when the flow is low, and the very late priorities are useful only in times of high or flood flow. In nearly all the western states it is necessary to apply to the state engineer or other official for a permit to make the appropriation. The distribution of stream water according to the respective priorities is supervised by the state engineer's organization or by commissioners appointed by the courts.

In eight western states the riparian doctrine has been abrogated, and the only way in which an irrigator can acquire a right to use stream water is by appropriating it under the statute. In the other nine western states the ripar-

Presented before the Soil and Water Conservation Division at the annual meeting of the American Society of Agricultural Engineers, at St. Paul, Minn., June 21, 1939. The author is irrigation economist, Soil Conservation Service, U. S. Department of Agriculture.

ian doctrine is recognized to some extent at least. Even in some of these states the doctrine has been materially limited by statute or court decisions, and to that extent is superseded by the appropriation doctrine. In California, one of the jurisdictions in which both doctrines are recognized, the riparian doctrine is underlying and fundamental; and there appropriative rights have become vested either because the appropriations were made on public land, or because appropriators made their diversions of water from upstream points for periods of years long enough to establish prescriptive rights to continue doing so, notwithstanding the necessities of the downstream riparian lands, or because the quantity of water in a stream was more than sufficient for the beneficial requirements of land riparian to the stream.

Concerning rights to the use of percolating ground waters, some western states follow the absolute-ownership rule and some the reasonable-use rule of the eastern jurisdictions. California has a modification of the reasonable-use rule called the correlative doctrine, which allows an apportionment of the water of an underground basin among the holders of all lands overlying it, when the supply in the basin is not enough for all. Under the California system, any surplus ground water above the reasonable requirements of overlying lands may be appropriated for use outside the basin. Several western states have statutes, which were passed for the most part in recent years, allowing ground waters to be appropriated, as in case of the waters of surface streams. In Utah, for example, all waters, whether above or under the ground, are declared by statute to be public waters and open to appropriation, subject to any existing vested rights to their use. In New Mexico, on the other hand, the ground waters subject to appropriation are those of underground streams, channels, artesian basins, reservoirs, or lakes, having reasonably ascertainable boundaries. The owner of land overlying waters which are determined to be in such classification, has no right to pump them out solely by virtue of the location of his land, but must first make an appropriation under the statute. But as to percolating ground waters in New Mexico which do not conform to the statutory definition of appropriable waters, the inference is that they belong to the landowner under the early court decisions.

INCREASING USE OF STREAM WATER IN THE EAST

Use of water for irrigation has not yet become a major problem in the East. Heretofore the main concern over eastern waters, aside from navigation and flood protection, has been the procuring of water supplies for municipal and domestic purposes, and matters of stream pollution. More recently, with the development of processes for air conditioning, has come the problem of requisite water supplies for that purpose, and in that connection rights to the use of ground waters have assumed increasing importance. Irrigation has been carried on in some localities for considerable time, but the aggregate area irrigated in the eastern states has not been extensive.

However, interest in irrigation is apparently increasing in the humid areas, primarily for the purpose of supplementing the natural precipitation and as a safeguard in periods of drought. Therefore, it is anticipated that the question of water rights, whether or not it is destined to become a major eastern problem, will become more important than it has been heretofore.

As the riparian doctrine is recognized throughout the East, rights to the use of the water of streams for irrigation purposes will rest primarily upon the common law of riparian rights, pending the enactment of statutes concerning water rights and, possibly, constitutional amendments in some states. The doctrine of prior appropriation, at least in the form in which it has been highly developed throughout the West, does not prevail in the East, although the taking of water for public purposes under legislative authorization is commonly practiced. However, the eastern states are as much at liberty to provide for systems of appropriative rights for any and all beneficial uses as were those of the West. The United States Supreme Court, in the recent decision in *Connecticut vs. Massachusetts,* declined to adopt the riparian doctrine as the basis for apportioning water between these two states, and stated that as each state is free to change its laws governing riparian ownership and to permit the appropriation of water, the riparian law that happened to be effective for the time being in both states did not necessarily constitute a dependable basis for settling the controversy.

THE LEGAL FUTURE OF EASTERN WATER RIGHTS

If, then, an eastern state does not provide by legislation for the use of water by other than riparian owners, it is probable that irrigation with stream water will be confined principally to riparian land, and that each riparian will be held to an equitable share of the flow at the time when other riparian owners wish likewise to use the water. It is possible, of course, that public-service companies may establish irrigation projects under the power of eminent domain, and may operate such projects under public regulation, as they do now in case of municipal and domestic water supplies. It is likewise possible that individuals or groups may divert water to nonriparian land for their own private use and may continue to use the water without protest from lower riparian owners; and if this use conforms to all the requirements of the statute of limitations and continues throughout the number of years prescribed by the statute, and thereby prevents water from reaching downstream riparian lands upon which it otherwise could have been used, these nonriparian diverters will thereby acquire prescriptive rights to continue the use, and the downstream riparians are thereafter barred from asserting any claims upon the quantity of water to which their rights of use are thereby lost. Such prescriptive rights, however, are good only as against downstream riparians. The unauthorized use by the nonriparian diverters is not adverse to upstream riparian owners, and therefore prescriptive rights do not run upstream.

If any extensive use of stream water for irrigation is to be made in the eastern states, aside from irrigation on riparian lands, the doctrine of appropriation offers a method by which such rights may be acquired and exercised in an orderly manner. To accomplish this purpose fully, an appropriation statute is necessary. It is possible of course that the courts might decide that the establishment of a local custom of appropriating water was justified in the absence of legislation. That at the most is problematical; and in any event the vital necessity which prompted the early custom of appropriating water for private irrigation use in the West, and which was later sanctioned by law, is not paralleled in the East. When conditions in an eastern state require the general use of stream water for the irrigation of nonriparian land, a carefully drawn appropriation statute appears to be the better means of making it legally possible.

Granted that an eastern state enacts an appropriation statute of general application, existing riparian rights will have to be given consideration, but it is not believed that they will interfere seriously with the operation of an appropriative system. There is precedent in the West for limiting the riparian right to the subdivisions of land which actually touch the stream, and for severing the right from ownerships away from the channel even *(Continued on page 436)*

Motor Fuels from Farm Products

By P. Burke Jacobs

IN RECENT years the term "power alcohol," which in itself is rather devoid of meaning, has become accepted as signifying a rather complicated technical and economic theory of utilizing suitable farm products to make alcohol for use in motor fuel. Proponents of this theory believe that it represents an adequate solution to current perplexing problems of farm income, unmarketable crop materials, and presumably inefficient agricultural methods and practices. To effect the movement seemingly would involve the rather unrestricted production of crops, and hence would develop an economic trend somewhat at variance with the present system. In order to bring the theory into practice, certain economic changes would have to be effected.

Because of certain well-known facts regarding losses of potential agricultural revenues through crop wastes and recurrent surpluses of products for which adequate markets cannot be found, any proposal which might afford a solution to the question of adequate farm income should be given intensive consideration. Certain facts are obvious. Our present agricultural operations do result in wide variations of crop supplies, with considerable fluctuations in price, and hence in farm income, while at the same time unsalable culls, by-products, and wastes represent losses of potential farm income. The existing situation has resulted largely from circumstance. But before any radical change of system is embarked upon, it would seem wise to give much study to any proposed new plan because of the serious dislocations that may ensue, particularly to ascertain whether under the proposed method more adequate results will be achieved than might be securable under the present system, and whether the proposed new plan will meet all the economic requirements, be efficient, be practical, and be applicable to existing conditions without undue secondary effects. Any *new* system should be a *carefully* planned one.

FLEXIBLE MARKETS NEEDED

To remedy present agricultural difficulties it is necessary to provide sufficient markets for practically all the utilizable products and by-products of the farm, at adequate price returns, and these markets must be flexible enough to absorb excess quantities of crops in good years, or to get along on smaller quantities of agricultural raw materials in poor crop years. Since it is doubtful if food or food uses can be much expanded, the solution does not seem to lie in that direction, for certainly the required flexibility of such a market would be difficult to achieve. Industry, therefore, must supply the agricultural raw material outlet. But the use of farm products in industry also has limitations. Better, cheaper, or more easily available raw materials are now in use in many instances. Markets for manufactured products are limited by the consuming power of the nation. To dislocate industry by enforced substitution of agricultural products for other raw materials, uneconomically, would only mean solving one problem and creating another.

The U. S. Department of Agriculture is especially interested in the possibilities of utilizing excess farm crops as raw materials for industry. At present, however, due to our national wealth of cheap raw materials, many of the proposed industrial uses for crops constitute economic border line problems. Among the many possible industrial applications, the most outstanding possibility is the production of alcohol from carbohydrate materials for use as an ingredient of motor fuel, since no other suggested industrial use approaches this one in potentiality, both in respect to the quantities of crops which might be thus absorbed without serious disturbance to existing industries, and the benefits that might indirectly return to agriculture. Here the market is large enough, and flexible enough, to meet the requirements of an agricultural disposal theory. Power alcohol proponents have made the most of this fact.

CONSIDERATIONS OTHER THAN COST

Ignoring for the moment the matter of present relative costs of alcohol and straight gasoline fuels, and the impact of any resultant cost increases on the nation in groups or as a whole, probably the only industry likely to be specifically affected by a power alcohol development will be the petroleum industry. To be fair to that industry the possible effect should be considered, but consideration may also be given at the same time to the matter of conservation of national resources, which is likewise involved, and which constitutes a further argument for the establishment of a motor fuel industry based upon agriculture.

Motor fuel supplies have become an outstanding requirement for national welfare, and countries which lack such supplies have been undertaking expensive and drastic measures to meet such needs. But the United States has been very fortunate in respect to natural fuel resources. However, the petroleum reserves of this nation are an unknown quantity. Total oil production to date has greatly exceeded original estimated reserves. The recent tendency has been to increase reserve estimates. The American Petroleum Institute on January 1, 1938, arrived at a figure of 15,507,268,000 barrels of reserves, which figure was about two billion barrels over previous official estimates. On January 1, 1939, they again revised this estimate upward to 17,348,146,000 barrels, due to new discovery, new horizons on old pools, improved refining methods, and other increases. Other reports exist, however, which tend to show that, on the basis of a continuing expansion of annual gasoline consumption, in about 3 to 5 years an increasing portion of the gasoline annually required in this country must come from new discovery. If that is a fact, it is a very serious one. Unquestionably, all the oil deposits below ground have not been discovered and exploration is proceeding continuously. We now consume about 1,200,000,000 barrels of crude petroleum annually, and therefore we have 15 to 20 years' supply in sight. Much can happen in 20 years. It would seem that the petroleum industry is now entering an era of waste conservation, whereby more efficient pumping and refining methods and use of waste gases as sources of synthetic fuels are increasing the potentialities represented in our known national oil reserves. The replacement of 10 per cent of the gasoline now produced, by its equivalent in alcohol, would mean a reduction of 10 per cent in crude oil production and gasoline refining. Since the petroleum industry would probably blend and distribute the blended fuel, such portion of the industry would be little affected by a power alcohol development. But certainly the life of the reserves in the ground would be extended

Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers at Saint Paul, Minn., June 20, 1939. Mr. Jacobs was then senior chemist, industrial farm products research division, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.

for an additional time. In the last analysis the petroleum industry will sell all the oil eventually, and therefore the life of the industry would be extended. Anticipated annual increases in gasoline consumption would probably absorb the volume of alcohol blend production without decrease of production of crude or refined petroleum.

REPLACEABLE AND IRREPLACEABLE RESOURCES

The outstanding fact is that at present we seem to be using up our oil reserves faster than any other nation in the world, and therefore we may reach the end of our reserves first. We have been supplying around 60 to 65 per cent of the world's consumption of petroleum, but it is doubtful if we have 65 per cent of the world's reserves. On the basis of known reserves we have considerably less than that amount. Twenty years is such a short time in the life of a nation, after all, that grave doubts as to the ultimate wisdom of our present scale of production and use of petroleum have been raised. Certainly steps to meet future contingencies should be taken before serious difficulties are encountered.

New wealth has always come from out of the ground. Coal, natural gas, and oil are irreplaceable. But agricultural materials are a product of soil, air, water, and sunshine. They are annually renewable, and may be produced continually since the fertility of the soil can be restored as required. If, as now may be anticipated, we are to be faced in the future with the necessity of finding other fuels to replace the present rather easily available materials which are being so rapidly exhausted, it would seem to be good judgment to create such new fuels from an inexhaustible source rather than the contrary. However, within the next decade it is doubtful if agricultural fuels could extend our fuel resources more than 10 to 15 per cent, although such amounts, and future greater amounts, would continue to become available more or less indefinitely.

Such arguments as these have been presented favoring the adoption of a system of power alcohol production aimed at solving the farm problem. Generally speaking, the desirability of conserving resources and improving farm economy as implied in all of these objectives may be conceded.

Considering the problem from an economic viewpoint, under present conditions gasoline is cheaper than alcohol, and therefore a cost differential exists which must handicap the commercialization of power alcohol. Recognition of this fact should be an immediate determining factor in any decision as to entrance upon the manufacture of alcohol for such purpose. The relative economics must be considered; however, because of the corresponding advantages to be derived, power alcohol may not necessarily have to be immediately economic, and aspects of future national advantage might justify incurring costs for which immediate adequate return cannot be visualized.

This criticism of the present proposals may be made. While certain of the hypothetical requirements as outlined previously have been met, the matter of plan has not been definitely formulated or even outlined in any published statement, so far as known.

Because of existing circumstances, before a power alcohol movement can hope to win economic stability, it would seem that certain fundamental understanding should be considered in advance, so that a definite plan can be formulated, by which obstacles might be avoided or surmounted. There should be first a definite concept as to the *reason* for the initiation of such program, and a definite understanding of purpose or objective, for example, whether it is to be a national conservation matter, affecting national resources, or basically an agricultural measure. Existing legal, social, and economic conditions may have to be modified to conform to any new program, since without such changes progress in the new field may be handicapped from the start. Much of the past difference of opinion as to the practicability of alcohol fuels has arisen because there was no common objective, or crystallization of ideas as to program. The *real objective*, and the *method* by which such objective is to be gained, should be clearly and definitely understood since different approaches may be required, or different fundamental conditions must be met, to achieve desired results. If conservation of existing liquid fuel resources is visualized, possible extra expense consequent upon introduction of agricultural fuels may be of minor importance, and a definite expansion of present crop production may have to be undertaken in order to make available sufficient raw materials to achieve some measure of conservation. Again, if a program is designed more particularly to aid agriculture, a decision should logically be made as to the extent of such program. If the mere utilization of present unsalable crop surpluses, culls, by-products, and wastes, is visualized to eke out farm income, certain definite limitations can be immediately foreseen as to quantities and costs of the alcohol. Such a scavenger industry would have very definite size and operation handicaps. If, instead, crop price advances are desired, as may be brought about through the removal of considerable quantities of crops from food or feed markets for industrial use, then other limitations can be foreseen, since such price advances will increase alcohol prices, to the detriment of sales. Again, an expansion of agriculture might be visualized as the principal objective, with fuel conservation as a secondary consideration. This again will entail a group of resultant circumstances. A further important and necessary decision should be made as to whether any program is to be effective on a *national* scale, under fixed conditions, or on a *local* scale under the resulting variable conditions.

NATIONAL RATHER THAN LOCAL PROGRAM NEEDED

Each of the alternatives mentioned presents a specific set of problems. A change of objective or of method during development of a power alcohol industry may not easily be accomplished. While undoubtedly a local or haphazard development of such an industry can be carried on and somewhat expanded for a short and indefinite period, eventually the limitations on such production will make it necessary to formulate decisions of the nature just outlined; meanwhile the struggling industry will have to combat the handicaps attendant upon the existing situation. Therefore, a clear understanding of aims and methods should be arrived at prior to undertaking the manufacture of alcohol from farm products.

Conceding the value of idealism, and foreseeing certain advantages which might be gained by the creation of such an industry, nevertheless from the investment standpoint there are two immediate handicaps to a national program, since, in addition to the matter of relative costs, the wherewithal for a national blend does not now exist in crops, manufacturing plants, or personnel. In perhaps five years this latter situation could be corrected, but meanwhile interim operations which would probably be local in character would have to bear the entire expense and trouble inherent to a development period. In the author's opinion it is preferable to base consideration upon a national, rather than on a local program. While a well-situated local plant, with plenty of cheap raw materials and good local markets for *all* products, can offer much promise of being economically sound, at least as to alcohol production expense, such plant will necessarily be faced with the higher distribution costs attendant upon the introduction of any new products.

One or a few plants would have insufficient weight to change existing legal, social, or economic conditions in the necessary degree to offset present differences of costs between alcohol and gasoline as fuel. A nationally sponsored industry might have relatively less difficulty in these respects, although such a national industry would be faced not only with present inadequacy of materials, but also with the necessity of using various raw materials in different areas. Since it is desirable to have a motor fuel which is standardized as to constitution and price, and since the costs of alcohol as produced from various materials would vary widely, a problem of *equalization of the cost* of such alcohol in *different areas* would arise. Also, on a national scale the diversion of the requisite quantities of crops to industrial use and the possible effects of such diversion on farm economy, especially on the feed and animal market situations, must be well considered.

In past years there has been much controversy as to the economic feasibility of using farm materials as a source of motor fuel. Protagonists and antagonists have derived opposite conclusions, such divergence of opinion frequently arising from the fact that crop yield statistics or alcohol production estimates were used which reflected the more extreme possibilities. Since crop yields in the past have ranged from very good to very poor, the figures selected in some instances probably represented the normal difference between optimism and pessimism without any deliberate intent of unfairness, and undoubtedly the statistical material had to be derived from many non-correlated sources.

STUDIES OF THE PROBLEM BY THE U.S.D.A.

The U. S. Bureau of Chemistry and Soils recently made an independent study of the power alcohol problem and assembled much data from various sources. Believing that such data might serve to clarify future discussion, much of the available material was recently issued as a bulletin under the title, "Motor Fuels from Farm Products" (Miscl. Pub. 327, Dec. 1938), in which the various angles of the alcohol motor fuel problem were brought together and correlated so that a comprehensive view of the entire problem might be obtained. As far as possible, factual matter was presented with a minimum of discussion, and statistics showing present actualities were assembled which depicted the probable ranges or variations in crop production, so as to establish acceptable averages. Much of the existing literature was reviewed and a summarization of the various findings was presented, in which an attempt was made to eliminate possible bias. It was hoped that this publication might be useful as a basis for future consideration of the problem. No new scientific research was done by the Department in connection with this publication. While perhaps not wholly successful in realizing the original objective in its entirety, it is felt that a reasonably comprehensive and fair presentation of the facts has been achieved. Copies of this bulletin may be obtained from the Department. Naturally, publication cost limitations made it necessary to omit much material which might logically have been included. Much has been left unsaid, and no actual conclusions on the future practicability of agricultural motor fuels were drawn, partly because of the need for much additional research on certain phases of the problem. Secondary or indirect benefits which might accrue to the nation or to agriculture from a power alcohol program were not discussed.

It was hoped that the assembly of data presented in the bulletin might indirectly discourage hasty or ill-advised rush of capital into power alcohol production. This hope was not founded on any intention of retarding the development of a replacement fuel industry, nor from any lack of interest in the use of farm materials industrially. But since it seemed clear that at present such manufacture verged on an economic border line, and that distribution, processing, and raw material supply difficulties would have to be faced and many problems solved, while profits, if any, would be small, a conservative viewpoint seemed advisable. The solving of the technical problems, so as to reduce alcohol costs and lower present disadvantageous differentials, is very important. Thus far the experimentation with alcohol fuels in this country has been financed almost wholly from public or semi-public sources, and the question of personal losses sustained by individual investors has not arisen to any extent. It was believed that this should continue to be the case until certain present obstacles to the economic use of alcohol blends have been surmounted.

MATERIAL SOURCE FACTORS IN COST OF ALCOHOL

Costs of alcohol from different materials will of course vary. Much research should be done to reduce costs. The greatest initial industrial development may be anticipated in the cereal crops, because they are the more concentrated materials, and therefore of greater present industrial interest, and represent the cheaper alcohol sources. Other crops, such as sweet potatoes, which offer larger acre return, are also of interest. Present costs of producing alcohol may be decreased in the future by simplification of production methods, since present processes are based on the production of a grade of alcohol which is of specific taste and odor. Since these are of no concern in motor fuel, deviations in process, equipment, and quality of raw materials are possible. Production costs can be separated into the items of labor, capital, and raw material. Both labor and capital costs might be reduced in processing a cheap grade of alcohol, and raw material costs reduced by use of lower grades. Cost saving in the matter of materials is harder to prophesy, since an adequate return to the farmer will be necessary, which may constitute a minimum limitation. At the same time, the securable return from by-product feed will be of great importance in determining the net cost of the raw material. Much experimentation will have to be undertaken in order to explore the various possibilities suggested by these alternatives. Since some reduction in alcohol cost may be anticipated and since future advances in petroleum fuel costs may also be conceived, a time may come when direct competition of straight gasoline and blended fuels will be possible.

The extent to which culls and crop by-products can be used, or the extent to which such materials can be collected and moved to a central refinery, will depend on the successful solution of various technical and economic problems, but fortunately most of these problems are seemingly not complex, and some degree of solution can be anticipated. Much of the process research needed will be undertaken in the new regional laboratories of the Department, particularly at Peoria. It is now proposed that a complete pilot plant for studying alcohol production problems and costs, for all likely crops, be erected at this laboratory. The work now projected will probably have a great bearing on the future practicability of alcohol fuels from farm products.

Based on the present situation, a power alcohol movement as heretofore proposed, founded on present crops and conventional methods of alcohol production, would have been quite expensive over the past few years. A rather arbitrary computation (in which the facts were followed as closely as possible) has been made and the figures tabulated for the situation which would have existed during the period 1930 to 1937, had the necessary legislation been in effect. The accompanying table is intended to show cost

ESTIMATED COST OF A POWER ALCOHOL PROGRAM DURING THE YEARS 1930 TO 1937

Year	Taxable gasoline consumed, gal	Corn harvested as grain, bu	Average corn price received by farmers, cents[2]	Relative alcohol cost from such corn, cents[3]	Gasoline cost, cents per gallon[4]	Producing cost of 10% blended fuel, cents per gallon[5]	Net increased cost of fuel, cents per gallon	15% of the corn crop, bu	Alcohol producible from such corn (at 2.3 gals/bu), gals	Potential U.S. revenue on gallons of motor fuel (10% blend) represented	Increased cost to motorists	Increased national motor cost if entire gasoline had been a 10% blend	U.S. revenue represented[6]
1930	14,761,309,000	1,757,238,000	59.6	0.360	$0.1616	17.64	1.48	263,585,700	606,247,110	$ 60,624,711	$ 89,724,572	$ 218,319,373	$ 147,513,090
1931	15,407,650,000	2,230,125,000	32.0	0.276	0.1298	13.94	.96	334,518,750	769,393,125	76,939,312	73,861,740	147,913,440	154,076,500
1932	14,250,173,000	2,576,407,000	31.9	0.275	0.1330	14.22	.92	386,461,050	888,860,415	88,886,041	81,775,158	131,101,591	142,501,730
1933	14,224,321,000	2,103,308,000	52.2	0.337	0.1241	14.04	1.63	315,496,200	725,641,260	72,564,126	118,279,525	231,856,432	142,243,210
1934	16,136,137,000	1,146,684,000	81.5	0.425	0.1364	16.02	2.38	172,002,600	395,605,980	39,560,598	94,154,223	384,040,060	161,361,370
1935	17,160,339,000	2,015,007,000	65.5	0.377	0.1355	15.47	1.92	302,251,050	695,177,415	69,517,741	133,474,063	329,478,508	171,603,390
1936	19,011,552,000	1,233,766,000	104.5	0.483	0.1410	17.02	2.92	188,064,900	432,549,270	43,254,927	126,304,386	555,137,318	190,115,520
1937[1]	21,208,977,000	2,343,258,000	55.1	0.348	0.1458	16.10	1.52	351,488,700	808,424,010	80,842,401	122,880,450	323,376,450	212,089,770
Total										$532,189,857	$840,454,117	$2,321,223,172	$1,321,504,580

[1]Estimates only.

[2]Season average price received by farmers (not Chicago price). Weighted average. Average of 8 years—60.3 cents per bushel.

[3]Cost per wine gallon, as estimated from the following assumptions: 82 wine gallons anhydrous alcohol secured per ton of corn (2.3 gallons per bushel). Feed credits based on 16 lb recovered per bushel of grain from the above assumptions is added 8 cents for conversion, 3.5 cents miscellaneous overhead costs, 3.5 cents sales cost and profit, and 2 cents freight allowance. Finished 99.6% alcohol, undenatured, in tank cars, f.o.b. base point. Malting costs are not included, but these will practically offset carbon dioxide and fusel oil credits. Average alcohol cost for the 8 years period, 36.0 cents per wine gallon. used, priced at cost of grain less $1.50 per ton for handling (28.6% recovery, or 571 lb per ton). No credit taken for fusel oil or carbon dioxide. To the raw material costs per gallon of alcohol as calculated

[4]Retail average for United States, exclusive of tax at service station (50 cities). It should be noted that the distributor margin is included in this figure.

[5]Credit of 0.5 cents per gallon allowed for increase in octane rating. No margin in distribution on the alcohol portion of the blend is included.

[6]Potentially lost if 1 cent tax had been removed on entire gasoline.

NOTE: For the period 1933 (part year) through 1935 inclusive, rental and benefit payments by the federal government for farmers on carbohydrate crops was as follows (Agricultural Statistics, 1938, page 432): Corn, $222,000,000; wheat, $315,000,000; rice, $10,000,000; sugar beets, $31,000,000; sugar cane, $12,000,000; total, $590,000,000. In the years 1936-1937, gross payments were made on a general program, without specific breakdown.

increases to the government and to motorists on the basis of recent proposals that the existing one-cent federal gasoline tax be remitted in the case of blends containing 10 per cent of alcohol produced from farm products. The figures will speak for themselves. This table disregards the fact that increases of octane rating of the gasoline used, as secured by the use of alcohol, might have been accomplished by other and probably cheaper methods.

Water Rights for Irrigation

(Continued from page 432)

though these latter tracts originally were part of one ownership which extended to the stream. A decision to this effect will materially limit the total area of land entitled to riparian rights. Again, the flow of many streams will doubtless exceed the beneficial requirements of all riparian land, so that the surplus can be declared to be public water available for appropriation. There is precedent in the West for defining and limiting riparian rights by statute. For example, an Oregon law which limits the riparian right to water actually applied to beneficial use prior to the enactment or within a reasonable time after it, has been upheld by the Supreme Court of that state and by the Federal Circuit Court of Appeals. Further, diversions which take water away from downstream riparian lands will eventually be safe from interference from the riparian owners if such owners fail to assert their potential rights, and will be protected against all other appropriations which are junior in point of time. In any event, it is hardly likely that small projects for supplemental irrigation will encounter serious resistance from riparian owners.

The adjustment of rights to the use of ground waters may involve some form of public regulation of the use of ground waters recognized as belonging to the landowner, or may be achieved through adoption of the appropriation doctrine. It may be reasonably anticipated that extensive development of ground waters in a state now holding to the doctrine of absolute ownership will result in a modification of that doctrine, as has been the case in the West. The modification usually first made is to hold the landowner to a reasonable use. There appears to be no reason why the exercise of reasonable use cannot be regulated under public administrative authority equipped to make scientific determinations of the nature and extent of ground waters in a given area. The state has adequate authority under its police power to regulate the use of property in the interest of the public welfare; and it may be noted in this connection that legislation in several eastern states has been directed toward the conservation of ground-water supplies.

An alternative is enactment of an appropriation statute. Here the legal and administrative difficulties are conceivably greater, but attempts are being made in the West to solve the problem along this line. It is true that the operation of the appropriation doctrine with regard to ground waters in the western states is still more or less in the experimental stage. Devoted as the West is to the appropriation of surface streams, it is not yet completely sold on the appropriation of percolating ground waters. There are warm advocates and vigorous objectors. Objections are based partly upon constitutional grounds, but largely upon the difficulties of applying the doctrine to waters hidden in the earth. The state engineers of several states, however, are now administering ground-water appropriation statutes, and are applying scientific principles to the determination of the origin and rate and direction of flow of ground waters, and their experiences should be valuable to administrators in other jurisdictions. If the eastern states enter this field, they too may develop experience of value to the nation as a whole.

Developments in Germicidal Lamps

By L. C. Porter
FELLOW A.S.A.E.

IN the General Electric research laboratory at Schenectady, Dr. L. R. Kollor has made some basic determinations that should be helpful in solving problems involving the use of sterilizing lamps. The following is a compilation of data from his and various other sources:

Humidity. The amount of humidity has a marked effect on the killing power of 2537 A (angstrom units) radiation of air-borne bacteria, as shown by the following test data:

Exposure	96% Humidity	61% Humidity	36% Humidity
	Per Cent B-Coli Killed		
10 seconds	82	99	100
5 "	*44	94	99
1 "	*57	90	87

*Probably experimental error

If we call humidities of less than 60 per cent low, and greater than 80 per cent high, we can state roughly that it requires approximately five times as much radiation to kill germs at high humidity as at low humidity.

Volume of Air per Tube. Tests indicate that the volume of air at 60 per cent humidity that can be sterilized by one 15-watt tube in a duct made of nonreflecting material is approximately 150 to 200 cu ft per min. This is independent of the size of the duct, because large ducts while they conduct some of the air at greater distances from the tube also result in slower air movement and therefore longer exposures which offset the lower intensity of ultraviolet.

If the duct were made of a material which is a good reflector of 2537 A radiation, such as alzak aluminum or chromium, the ultraviolet intensity would be increased considerably with a corresponding increase in the volume of air that could be sterilized per tube. Provision should be made, however, for regular and thorough cleaning of tube and reflecting surfaces of the duct.

Lethal Dosage for B-Coli and Moulds. The lethal dosage for B-Coli (which is perhaps more difficult to kill than some of the more dangerous bacteria) is approximately 6600 microwatt-seconds of 2537 A radiation. It seems to make little difference whether a long exposure of low intensity or a short exposure of high intensity is used. Some idea of the exposures necessary with a single tube and no reflector at various distances may be had from the following:

Distance from Tube	Exposure
3 in	7 sec
6 in	15 sec
1 ft	40 sec
2 ft	1¾ min
4 ft	7 min
8 ft	20 min
16 ft	2½ hr

An exposure of 18 min at 10 in is required to kill B-Coli contained in a film of greasy dishwater.

Moulds require exposures of 40 to 80 times as long to kill as B-Coli.

Depreciation. Tests to date indicate that the ultraviolet output of the 15-watt tube is approximately 80 per cent of initial at the end of 1000 hours burning.

Temperature. Apparently B-Coli kill as readily at 100 F as at 52 F. The ultraviolet output of the tube is however materially reduced by low temperatures. In still air it will be approximately 60 per cent of normal at freezing and 30 per cent at zero. In a breeze it is approximately 25 per cent of normal at freezing and 10 per cent at zero.

Ozone. The sterilizing tubes generate a small amount of ozone, somewhere between 0.004 and 0.075 parts per million cubic feet of air passing the tube. Ozone is helpful in killing bacteria and reducing mould. Ozone blown on B-Coli without any direct radiation hitting the germs required approximately 1½ hours to be as effective as a 30-second exposure to the direct radiation.

Ozone can be tolerated by human beings only in very limited amounts (probably less than 0.1 part per million parts of air) without becoming irritating.

Dr. Kollor's tests indicate the ozone from one 15-watt tube in a 500 cubic foot room with still air to reach a concentration of approximately 0.17 parts per million. With the room ventilated with eight changes of air per hour the ozone content was reduced to 0.07 parts per million.

Effect on Eyes. Short exposures close to the lamp will cause severe conjunctivitis. Where the lamps are mounted above the normal line of vision and several feet away there is little danger from being under the lamp for an hour or so. However, glasses or even a celluloid eye shade should be worn as an added protection.

Erythema. These lamps will cause erythema. The author spent two days at his desk with one 15-watt sterilizing lamp burning 8 feet directly in front of and 18 inches above the level of his face. Erythema to the extent of some peeling of the skin resulted. In another office, where two of the tubes were mounted at the ceiling and approximately 15 feet from one of the stenographers, she obtained a slight erythema. Incidentally, there was no detectable ozone odor in the first case, and a slight indication of it in the second. At five feet probably two to three hours is as long as bare skin should be exposed to the lamp, and perhaps one-half hour at two feet, and not over 5 minutes at one foot.

Comparison with Other Sources. The following data were obtained from tests of single tubes and are therefore only approximate. All measurements were made at 10 inches from the bare tube.

Source	Mw/cm² of 2537 at 1 meter	Seconds exposure to kill B-Coli
18-inch 15-watt sterilizing tube	25.0	20 seconds
350-watt quartz uviarc	31.9	10 seconds
5-watt sterilizing tube	1.4	12 minutes

The principal fields in which sterilizing lamps have been used are for the killing of air-borne bacteria in hospitals and sterilization in food industries, particularly in meat storage refrigerators, in bakeries, in the sterilization of dishes, tableware, tumblers, etc. The 15-watt tube having an initial output at 2537 A of 20 to 25 microwatts per square centimeter at 1 meter would be useful in these fields. The 5-watt tube has a much lower output, probably not over 1 microwatt per square centimeter at 1 meter. It is expected that this lamp may *(Continued on page 438)*

A contribution of the A.S.A.E. Committee on Electric Light for Insect and Bacteria Control—S. G. Hibben, B. D. Moses, C. C. Pink, L. C. Porter and T. E. Hienton (chairman). The author is illuminating engineer of the General Electric Company.

Short-Wave Radiation in the Control of Fungi and Bacteria

By Samuel G. Hibben

INTEREST in the practical applications of radiant energy (produced electrically) chiefly of the quality or wave length between 2000 and 3000 A (Angstrom units) has increased mightily, and the subject promises to become one of major importance in both plant and animal husbandry. Accepting the fact that the peak of lethal action on most micro-organisms occurs at about 2550 A wave length (a quality of radiation not found in sunlight at the earth's surface), it became necessary to perfect during the past few years the low-pressure mercury vapor discharge lamps or tubes, including accessories, which would have uniform regulated output of this quality. Earlier glass was too variable, and much had to be learned about the important production of ozone.

The user can purchase at least four different commercial lengths, 10, 20, 30 in, and one having a 1.5-in arc. Complete units are available with reflectors, including safety sockets and a housed transformer with operating switch, all with Underwriters' approval and necessitating no greater trouble to install than a simple lighting fixture.

The only hazard of usage is close range exposure of the eyes to the radiation, this causing conjunctivitis or temporary inflammation of the eyes. However, in recommended services there would be no occasion for such exposures.

The standard types of fixtures are designed for mounting from the ceiling, or in some instances locally over tables or benches, or in air ducts. If human operators are required to work in the field of radiation, they are preferably protected by hoods or eye shields and from artificial sunburn by harmless skin lotions. In many cases these ultraviolet radiators are installed as in meat storage cabinets or refrigerators and hence are enclosed and protected, or if in cabinets, or beneath hoods to irradiate food containers, drinking glasses, or materials in preparation, are shielded by ordinary plate or window glass which is opaque to any harmful (and also to bactericidal) radiations.

Direct Irradiation of Subjects or Materials. It is reported that a few moments close-range direct irradiation of drinking glasses, eating utensils, open containers, etc., will produce practical sterility of surfaces that the rays may reach. In canning and packing, one usage has been the sterilization of the surface before sealing, extended also to the maintenance of a sterile condition as in churns, buckets, and liquid containers when wholly or partially empty.

Under some circumstance it has been reported practical to irradiate seeds, bulbs, and portions of plants either to destroy small organisms or surface mold, although the prevention of the growth of mold by sterilization of the air, or the killing of the air-borne seed or spore, seems much easier than the elimination of the rooted growth. Available data on this usage are meager.

Space Irradiation. Installations of these lamps in poultry sheds have reduced the germ count and apparently lessened the spreading of disease affecting the pulmonary tract. Uniform space sterilization is being investigated, applying some four lamps to a floor area on the order of 300 to 400 sq ft or some 750 cu ft of air per lamp. With continuous burning it is said that the bacterial contamination has been reduced by some 75 per cent.

In meat storage chambers the combination of direct and of general space irradiation has proved effective provided proper conditions of humidity and air circulation are maintained, while the reduction of moldforming spores in places where baked goods are prepared, and the eventual prolongation of the keeping time of the food, is rather well established. Sterile storage of the milking machine, for instance, in a closed cabinet where the selective ultra-violet radiator is installed, is recommended.

In the domestic household refrigerator a small sterilizing lamp is generally useful and effective through the apparent medium of a carefully adjusted and accurately controlled quantity and quality of output to maintain nearly sterile air.

Therapeutic and Healing Applications. Differing from the so-called sunlamps or health lamps and limited as yet to usage by medical practicians, or in hospitals, there are special short-wave ultra-violet lamps, one known as the bactericidal thin-window lamp from which the chief output is in the general region of 1850 to 2500 A and which has evidence of rapid action in sterilizing wounds and surface abrasions, controlling some skin diseases, and reducing the spore which causes superficial troubles such as "athlete's foot". This development is of interest to the agriculturist for the treatment of animal wounds or for surface sterilization under conditions where liquid applications would not be practical.

General Costs of Installation and Operation. Depending upon installation conditions, it is generally assumed that the installed cost of a sterilizing lamp unit approximately 3 ft long and complete with reflector and controlling accessories would be on the order of $30. Well-made ultraviolet tubes have a long life, capable of burning continuously for about half a year. The electric power consumed is quite small, since four 30-in lamps require about the same power from the line as a single 75-watt Mazda lighting lamp.

A contribution of the A.S.A.E. Committee on Electric Light for Insect and Bacteria Control—S. G. Hibben, B. D. Moses, C. C. Pink, L. C. Porter, and T. E. Hienton (chairman). The author is director of applied lighting, Westinghouse Electric & Mfg. Company, Lamp Division, Bloomfield, N. J.

Developments in Germicidal Lamps

(Continued from page 437)

be used in domestic refrigerators and small containers such as tooth brush holders, etc.

The 5-watt sterilizing tube is approximately 1¼ inches in diameter and 7¾ inches overall. It is equipped with a medium screw base containing a series resistance. Current consumption is approximately 50 milliamperes. The tube requires about 10 minutes to come up to full output at 70 F. (At 40 F the starting is slower and the ultraviolet output is reduced about 20 per cent.) Its output of 2537 A is approximately 1 microwatt per square centimeter at 1 meter. Killing time for B-Coli Communis is 16 minutes at 10 inches.

AUTHORS NOTE: Since this data was originally prepared a 3-watt germicidal lamp has been announced. This lamp is a U-shaped tube of approximately 5⅜ in overall length and of ½ in diameter. Its ultraviolet output of 2537 A is approximately four times that of the 5-watt tube. A small reactor is used in series with the lamp.

Basic Problems in the Air Conditioning of Stables

By M. A. R. Kelley
FELLOW A.S.A.E.

WHILE farmers have always known that adverse environmental conditions affect production, the engineer wishes to have measures of these losses to guide him in design of suitable structures. Over a period of years physiologists have made many tests of the metabolism of farm animals, but most of these tests have been with respect to the basal metabolism. I should like to emphasize that in order to design efficient structures for farm animals, engineers need to know more about the heat and moisture production under normal feed and throughout the ordinary range of temperature and humidity conditions.

The present state of development of insulating materials and air-conditioning apparatus makes possible the maintenance of almost any desired condition. Many people would say offhand that it is impractical to apply these modern inventions to buildings for animals, but we know that practices change and means of reducing the expense of new kinds of equipment are gradually developed.

Only about twenty-five years ago a New England state college published a statement that winter climatic conditions were too severe in its state for profitable raising and handling of dairy cows. Proper insulation was unknown then, but now many successful dairy herds are kept in modern barns in that state.

HEAT AND MOISTURE PRODUCTION AS FACTORS TO BE CONSIDERED IN SCIENTIFIC DESIGN

The agricultural engineer cannot entirely change adverse economic conditions, but he can help immensely in changing a mediocre performance to a successful and profitable farm business. Many large semi-commercial farm enterprises are being developed and ask for technical help. Multistory poultry houses with capacities from 4,000 to 60,000 birds or more are examples of enterprises where careful design and efficient management may mean the difference between success and bankruptcy.

Scientific design is impossible without data on heat and moisture production under the conditions that can reasonably be maintained, both in winter and in summer. In fact, methods of improving conditions in hot weather are perhaps as urgently needed as methods for providing comfortable conditions during cold weather, but the former has had less attention. I have studied the work of various investigators that bear on this subject of summer comfort for farm animals, and should like to present a composite picture that perhaps may have far-reaching implications in the solution of this problem.

Tests made in cooperation with the University of Wisconsin and Brookhill Farm[5]* from 1930 to 1932 were intended primarily to show the effect of winter environmental conditions upon the milk and butterfat production of milk cows, but it was recognized that the record of the body temperatures, respiration, and pulse of the individual cows might produce a more sensitive measure of the environmental conditions than the ordinary thermometer, Babcock tester, and milk pail. In this series of tests the cows were fed normal rations, and there is every reason to think that during most of the time the cows were comfortable. Therefore, the very complete records of production and physiological conditions that were taken can be used as a sort of bench mark or starting point for comparison with other tests such as those in California[7] and Louisiana[8], which will be referred to later.

A summary of average body temperature, number of respirations per minute, and number of pulse beats per minute for all cows in the Brookhill tests is included in Table 1 and will be used for comparison with similar data obtained in California under warm conditions.

In this test, with stable temperatures between 46 and 65 F (degrees Fahrenheit), the herd averages of body temperature of the cows was about 101 F, pulse varied between 61 and 70 per minute, and respiration per minute varied from 17.6 at 46 F to 29.4 at 64.5 F. Naturally there was much more variation in the records of individual cows. For example, during December two of the Brookhill cows, A4 and B2 had body temperatures of 103.8 and 103.2, though they showed no signs of sickness. Under a uniform stable temperature of 60 F their rates of respiration and pulse beat were, respectively, 26.5 and 30.5 breaths and 88.5 and 79.5 pulse beats per minute.

RESPIRATION RATES INCREASED AT HIGH TEMPERATURES

Studies in the psychrometric room and respiration chamber at the University of California have produced interesting results and reveal certain facts which had previously not been suspected. For example, Regan and Freeborn[7] made studies of the effects of flies and the use of fly sprays on milk production. They found a loss of milk production as high as 21 per cent in the presence of an excessive number of stable flies, which is important. But they also found

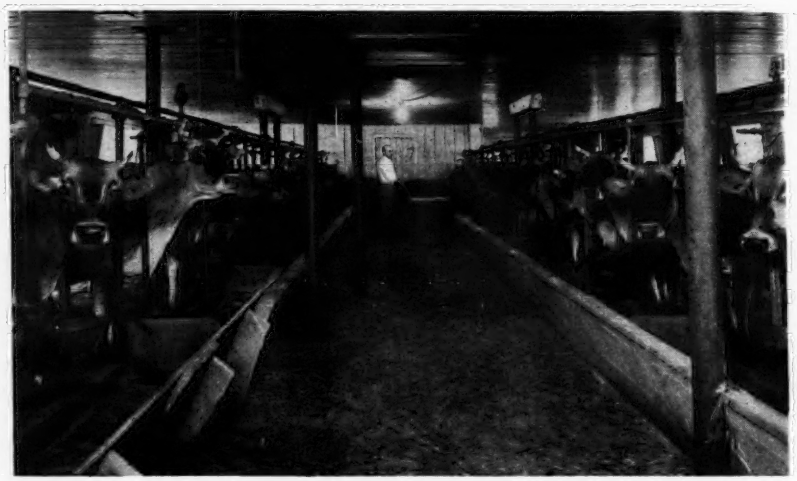
TABLE 1. COMPARISON OF SUMMER AND WINTER ENVIRONMENTAL TEMPERATURES AND THEIR EFFECT ON BODY FUNCTIONS OF A DAIRY COW

Variable summer environment* Maximum daily			Uniform winter environment** Average daily			
Temperature			Temperature			
Chamber deg	Body deg	Respirations per min	Stable deg***	Body deg	Respirations per min	Pulse per min
102	103.2	85	64.5	101.33	29.4	69.5
101	103.5	85	60.0	101.04	26.9	67.3
100	102.8	90	59.7	101.20	28.2	67.8
100	103.5	100	56.7	101.15	21.5	66.3
98	102.9	90	55.6	100.97	23.6	66.8
96	102.8	88	55.2	100.90	22.1	66.0
92	103.0	77	55.2	101.00	22.4	62.9
92	102.2	70	51.3	101.14	19.3	61.2
82	102.6	71	46.0	100.99	17.6	64.1

*Data obtained from California; see reference 6; average temperature not available.
**Data from Brookhill tests; see reference 5 for more complete record.
***Data for 65 F stage was taken from stable C; all others from cows in stable A.

Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers at St. Paul, Minn., June 21, 1939. The author is agricultural engineer, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.

*Superscript figures refer to literature cited at the end of Mr. Kelley's paper.



COWS PRODUCE MOST EFFICIENTLY WITHIN A CLOSE RANGE OF TEMPERATURE AND HUMIDITY CONDITIONS. DESIGN TO MEET THIS REQUIREMENT MUST BE BASED ON THE COWS' CONTRIBUTION OF HEAT AND MOISTURE, INSULATION AND VENTILATION INFLUENCES, AND STRUCTURAL RESISTANCE TO DETERIORATION UNDER THESE CONDITIONS

some new things about the temperature regulation of the cow. I should like first to compare the temperature and rate of respiration of cows under summer conditions with those in the Brookhill tests under winter conditions, as shown in Table 1.

It is of particular interest and significance to note that at a maximum air temperature of 82 F in the California tests the respiration rates were more than double those at Brookhill at 65 F, and that at air temperatures above 92 F, feverish body temperatures resulted and respiration greatly accelerated.

While we have no measure of the depth of breathing or cubic feet of air breathed per minute in these tests, Klieber and Regan[6] do provide information regarding this under warm and cold environmental conditions. Table 2 is a summary of some of their results.

It is noted that under the cold environment of 42 to 48 F, which is probably below that of the critical temperature of lactating cows[2], the respiration rate is low, is not definitely affected by the temperature of either hot or cold inspired air, and the depth of breathing is slightly more for the warm air. This suggests that under these conditions the skin temperatures controlling the rate of heat loss make little demand on respiration to balance the heat production and loss. This is contrasted with the hot environment, which calls for two-thirds the rate of respiration when cold air is breathed over that of hot air. It appears that the invigorating effect of the cold inspired air is accompanied by somewhat deeper breath, and that a less volume of air is required to produce the required cooling effect. The Brookhill test afforded added evidence of these reactions. The California tests give results which are indicative of the possible effects, and more complete tests are needed that will establish the upper and lower critical points and the optimum conditions.

TABLE 2. A STUDY OF RESPIRATION RATE AND VOLUME OF AIR BREATHED WHEN BREATHING HOT AND COLD AIR UNDER HOT ENVIRONMENT, ALSO SAME COMPARISON FOR COLD ENVIRONMENT[6]

Temperature		Respirations	Depth of	Air breathed	
Chamber deg	Inspired air deg	per min	breath	Per minute litres	Per hour cu ft
Hot 89.6–98.6	(Hot, 87.8–96.8	46.0	2.2	105	222.4
	(Cold, 39.2–59.8	28.0	2.7	82	173.7
Cold 42.8–48.2	(Hot, 87.8–96.8	15.4	3.6	55	116.5
	(Cold, 39.2–59.8	15.4	3.4	52	110.1

The reactions of the cows sprayed with oily sprays in this test may have implication of more significance than is generally realized. During the period of high temperatures the oiled cows were in extreme distress, and the sprays appeared to impair the efficiency of their thermo-regulating mechanism. The sprayed cows had an extremely rapid respiration rate of 130 per minute and a body temperature of 105.1 deg.

It was observed in the Brookhill tests that the skin and the hair of the test cows under a stable temperature of 65 F or more became moist and that the coat was harder to brush and keep clean. In conversation, it has been learned that this has also been observed by others but is not general knowledge.

WATER LOSS AND TEMPERATURE CONTROL BY SWEATING AND OSMOSIS

Therefore, it is of particular interest to find in the California tests that the hourly loss of water at 84 F and 60 per cent humidity was 413 grams from the body of the unsprayed cow and 223 grams for the sprayed animal; in other words, 31.8 per cent of the total heat was lost by evaporation in the first case, as compared to 24.6 per cent in the second. Since this water was analyzed and found to contain no appreciable chlorides, it was concluded that the water loss was due to osmosis.

Textbooks hold that cows do not possess sweat glands, which is doubtless true in the larger sense for the *Bos taurus*, but as discussed later, is not true for *Bos indicus*. From this it has been implied that moisture is not lost through the skin. Regulation of body temperature through evaporation of moisture from the skin is of great importance in man and many other animals, and these tests imply a similar reaction, but in a narrower range, in the case of the cow. Therefore, I have the temerity to raise a question and ask for more information about this form of temperature regulation in the case of the cow, and how her deficiencies in this respect can be overcome. In search for the answer to this question, the agricultural engineer is forced to look from the fly spray studies in California to England to study of man, and cross-breeding of livestock in Louisiana and in far off Australia, and then to assemble those thoughts which may lead to a solution of the problem.

The studies of Dr. Whitehouse[9] of England on sweating and skin permeability of man show that water may be lost from the skin in two ways: (1) evaporation from the sur-

face of water which permeates through the skin, and (2) evaporation of the trickling sweat secreted by the glands. As the air temperature rises, the loss of water through the skin increases rapidly and when at rest with the air of ordinary dryness, practically the whole loss was osmotic until the temperature reached 85 F, and most of it was osmotic until the temperature was well above body temperature. Other things being equal the osmotic passage of water through the skin varied with the depression of vapor pressure outside the skin and that of the vapor pressure of the blood. At 101 F the osmotic loss was 117 grams per hour, representing a heat exchange equivalent to that of the total ordinary resting metabolism of man. It is important to note that notwithstanding the presence of sweat glands the larger part of the water was lost by osmosis through the skin, and that the temperature of 85 F is an upper landmark. Thus these tests on man are in close agreement with those on the cows in California tests. Another interesting phase of Whitehouse experiments concerns the measurement of the transference of CO_2 and O_2 through the skin, starting at 49 F and increasing rapidly as the temperature rises. Amounts up to about 2 per cent of the volume ordinarily given off by the lungs were observed.

The unfavorable effects of high temperature on cows in the California studies are substantiated by other observations. It has been reported that on hot summer days with high humidities, high-producing cows may drop in milk production from 7 to 20 lb in a single day. The prevalence of warm conditions in some localities justify the use of cooling devices to mitigate these losses. The Georgia Agricultural Experiment Station[3] showed that the evaporative cooling principle may be used on cows by applying light blankets sprayed with water. This was found to be effective in maintaining milk yields and no harmful effects are recorded. Also, a large dairy farm in Massachusetts[1] during a hot day last summer found that a ton of dry ice used together with large fans to hasten cooling of 178 cows succeeded in cooling the temperature of the stable by 23 deg and an increase of 84 quarts of milk the next day resulted. Even with high milk prices, this would fall short of showing a profit, but illustrates that comfortable cows do produce more milk.

BREEDING INFLUENCES ON SHELTER REQUIREMENTS

While engineers can no doubt design structures and equipment to maintain conditions under which cows will give maximum yields, this may not be economically feasible in all sections, even if allowance is made for the advances in technical knowledge that we can feel sure will be made. Therefore, I should like to call attention to the work of some animal breeders that may simplify the problem that the engineer is called upon to solve.

In Rhoad's tests the effect of atmospheric temperatures and humidity, solar radiation, and shade on the respiratory rate, body temperature, and grazing habits also were observed. Obviously, our time does not permit much discussion of this test, but it is important to note that, when exposed to direct solar radiation under summer climatic conditions, the respiration rate and body temperatures of *Bos taurus* cattle tend upward toward a febrile condition when exposed for a considerable length of time. This febrile condition was not produced by Brahman cattle of the *Bos indicus* species which appear to have a more efficient means of disposal and resistance to excess body heat. This faculty, it is shown, may be transmitted by crossbreeding with the *Bos taurus* species.

Comparing the two breeds on a hot summer day of 88 F, the body temperature was 104 F with a respiration of 125 for the Angus, as contrasted with 101 F and 24 for the Brahman. Although the Angus cattle appeared comfortable at morning temperatures of 55 to 58 F, Brahman cattle were visibly uncomfortable, showing ruffled coat and some shivering, whereas with the Brookhill cows this condition did not become apparent until a temperature of 46 F was reached. Clipping the Angus cows appeared to add to their discomfort when subjected to the direct rays of the sun.

Kelley[4] of Australia provides us with evidence that *Bos indicus*, the Brahman cattle of India, do have sweat glands and suggests that our familiar *Bos taurus* may have possessed these at one stage of their evolution, but having developed in the cooler climates their sweat glands have atrophied and are now difficult to find, whereas the Brahman cattle developed in the warmer climate possess sweat glands and the number per square inch may be counted by aid of a suitable microscope.

Rhoad[8] of Louisiana found that by crossing Aberdeen Angus cattle with the zebu or Brahman cattle of India, the pyrexial point, and ability to withstand heat was raised from that of the Angus purebred, by the quarter-bred and half-bred toward the higher resistance of the purebred Brahman. In this case there is a mixing of two breeds, one from *Bos taurus* species and the other *Bos indicus*. This suggests possible future development and improvement of cattle for southern conditions.

A notable example of this possibility was witnessed a few years ago on the famous King Ranch of Texas. Here the Shorthorn and the Brahman have been crossed and a new breed, the Santa Gertrudus, developed, a living model produced by a master breeder which the artist and sculptor may envy. These experiments reveal a possible change in the natural cooling of cattle and their ability to resist heat.

In closing, the engineer needs to have further knowledge of the effects of normal environmental conditions on farm animals. For such information we are dependent upon calorimeter tests under controlled conditions, in order that the variable factors may be reduced to a minimum.

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NEWS

A.S.A.E. Fall Program Takes Shape

A PROGRAM based as far as possible on a consensus of all the expressed desires and suggestions received from members of the American Society of Agricultural Engineers has been built up for the Fall Meeting of the Society, to be held at the Stevens Hotel, in Chicago, December 4 to 8. Copies of the program as completed up to time of printing are now in distribution and may be obtained on request to the A.S.A.E., St. Joseph, Michigan.

Majority preferences supported the arrangement utilized Monday, December 4, for meetings of the Council, Jury of Awards, and other groups as desired; Tuesday and Wednesday for concurrent sessions of the Farm Structures and Power and Machinery Divisions; and Thursday and Friday for concurrent sessions of the Rural Electric and Soil and Water Conservation Divisions.

Evenings are available for continuation of afternoon programs, group round tables, committee meetings and special features.

FARM STRUCTURES

Farm home modernization, engineering problems of the ever-normal granary program, and farm building appraisal and valuation are the general subjects to which the Farm Structures Division will devote three of its sessions.

Opening its program Tuesday morning, December 5, the farm structures group will conduct a symposium on "Farm House Modernization." Contributions scheduled include "A Program for Farm House Modernization," by Miss Ruby M. Loper; "Problems Encountered and Aims of Farm House Remodeling," by H. E. Wichers; "Problems and Progress in Low-Cost Rural Housing," by Deane G. Carter; "The Farm House and the Architect," by Fred M. Overby; and a round table on "Possibilities of Coordination in Promoting Farm House Modernization," with contributions by Miss Mary A. Rokahr, Kirk Fox, and T. A. H. Miller.

"Engineering Problems of the Ever-Normal Granary Program" will be handled as a symposium at the afternoon session. It is to include papers on "Progress of the Corn Storage Program," by Wm. McArthur; "Report of Research Work in Corn Storage," by H. J. Barre, discussed by I. D. Mayer; "Progress of the Wheat Storage Program," by E. J. Bell, Jr.; and "Report of Research Work in Wheat Storage," by C. F. Kelly, with discussion by F. C. Fenton.

This program is to be continued in the evening from the standpoint of "Storage Structures to Meet Requirements of the Ever-Normal Granary Program." Five scheduled contributions are "Development of a Small, Low-Cost Concrete Storage Bin," by G. B. Hanson; "Steel Bin Design for Farm Storage of Grain," by R. E. Martin; "Steel Grain Bins," by W. B. Larkin; "Grain Storage Structures of Reinforced Clay Masonry," by C. T. Bridgman; and "Lumber Structures for the Farm Storage of Grain," by L. W. Smith.

Angles and speakers on "Farm Building Appraisal and Valuation" include "Farm Requirements for Good Buildings," by R. C. Miller; "The FSA Approach to Farm Buildings," by Baird Snyder or K. K. King; "Adapting Buildings to the Farm," by J. C. Wooley; "Appraisal of Insured Farm Building Risks," by L. G. Keeney; and "Report of the Committee on Farm Appraisal," by F. H. Schreiner.

Miscellaneous timely subjects not covered in the preceding sessions and scheduled for Wednesday afternoon include "A One-Story Dairy Barn Experience," by H. H. Musselman; "The Agricultural Engineer's Interest in Small Items of Prefabricated Structural Farm Equipment," by D. H. Malcom; "Technical Facts about White Lead and Red Lead Paint," by F. E. Wormser; "The Structural Application of Glue to Farm Buildings," by Henry Giese; and "Recent Developments in the Manufacture and Use of Lumber," by N. T. MacKenzie.

POWER AND MACHINERY

Pneumatic tires, farm production and processing of products for industrial use, and the U. S. Tillage Machinery Laboratory are general subjects each scheduled for the attention of one full session period of the Power and Machinery Division.

Its initial session Tuesday morning will feature "A Service Program for Farm Equipment," by R. J. Kretz; "Mechanization of a Southern Plantation," by H. H. Hopson, with discussion by Wm. E. Meek; "Progress Report on Malt Barley Harvesting Problems for Minnesota and North and South Dakota Conditions," by A. J. Schwantes, and "Traction of Light Tractors and Unit Plows," by A. W. Clyde.

In the afternoon the pneumatic tire session will feature "Pneumatic Tire Research Study (Report of A.S.A.E. Committee on Transport Wheels)," by E. G. McKibben; "Results of 1939 Field Studies of Dual Tractor Tires," by C. W. Smith and by E. C. Sauve; "Effect of Liquid Ballast on Bouncing of Tractor Tires," by H. W. Delzell; and "Rubber Tires for Farm Vehicles," by W. S. Lockwood. The Committee on Transport Wheels has also scheduled a discussion meeting for the evening.

Starting the Wednesday program is a symposium on "The Production and Processing of Farm Products, By-Products, and Wastes in Relation to Their Utilization by Industry." Arnold P. Yerkes is scheduled to present opening remarks on "How Agricultural Engineers May be of Service." E. C. Lathrop will tell about "The Place of Engineering in a Program of Farm Waste Utilization." W. H. Goss will discuss "Technologic Problems in the Processing of Soybeans." D. Howard Doane is to present "The Role of the Agricultural Engineer in the Farm Chemurgic Movement from the Standpoint of Agriculture," and Dr. H. E. Barnard will deal with the angle of "Engineering Aspects of Handling Farm Chemurgic Crops." L. F. Livingston will suggest possible work for agricultural engineers in "Preparation of Agricultural Raw Materials for Use by Industry."

In the symposium on "Possibilities and Activities of the U. S. Tillage Machinery Laboratory" G. Douglas Jones is to lead off with a presentation of "What the Laboratory Offers the Farm Equipment Industry." "Activities of the Tillage Machinery Laboratory" are to be reported by R. M. Merrill. Specific studies to be explained are "Laboratory Studies of Soil Reactions on Disks," by E. D. Gordon; and "Comparing Soil Packing Effect of Tractors by Use of a Soil Resistance Recorder," by I. F. Reed.

A "Progress Report on Power Take-Off, Drawbar-Hitch, and Belt-Pulley-Drive Recommendations" is also to be presented at this session by H. W. Gerlach.

SOIL AND WATER CONSERVATION

Unity of technology, interest, and purpose in soil and water conservation is emphasized in a program dealing with drainage, irrigation, and erosion and runoff control without exclusive concentration on any one of these subbranches in any one session.

The first session of the Soil and Water Conservation Division on Thursday morning, December 7, will feature contributions on "Planning Gully Control," by H. G. Jepson; "Recent Studies at the Spartanburg Hydraulic Laboratory," by W. O. Ree; "Drainage in Relation to Soil and Moisture Conservation," by Lewis A. Jones; "Drainage Investigations of the Farm Credit Administration," by Don H. Bushnell; and "Snow Surveys," by R. A. Work.

Thursday afternoon's schedule includes "The Highway Engineers' Responsibility to the Farmer," by Arnold M. Davis; "The Relationship of Agricultural Engineering to the Flood Control Problem," by Dr. M. L. Nichols and E. R. Kinnear; "Techniques for Hydrologic Research," by H. S. Riesbol; "Instruments for Hydrologic Research," by W. H. Pomerene; and "Plans for the Development of Irrigation in the Great Plains Region," by W. G. Sloane.

For the third session of the Division, on Friday morning, the program calls for consideration of "The Broad Furrow Method of Irrigation," by Colin A. Taylor; "An Analysis of Length and Degree of Slope Data as Applied to Terrace Spacing," by A. W. Zingg; "Runoff Studies of the Soil Conservation Service Project Near Edwardsville, Illinois," by W. W. Horner; "Factors Affecting Costs of Irrigation Pumping," by I. D. Wood; and "The Measurement of Velocity of Sheet-flow," by Dr. Robert E. Yoder.

Titles and speakers for the closing session are "Surveys for the Rehabilitation of Drainage Systems," by Clark E. Jacoby; "Developments in the Small Water Facilities Program," by N. R. Bear; "A New Picture in an Old Frame," by C. A. Frye; and "Pondage Corrections Involved in Measuring Runoff from Small Drainage Basins," by D. B. Krimgold and John L. Weber.

RURAL ELECTRIFICATION

New developments, ideas, and problems will be featured along with progress in the old in the Rural Electric Division program. The opening session on Thursday morning, December 7, will give consideration to "Results of a Survey of the Use of Electric Heat for Curing Sweet Potatoes in the

(Continued on page 444)

ASAE Meetings Calendar

December 4-8—Fall meeting, technical divisions, The Stevens, Chicago, Ill.

CULTIVATING CORN . . . 1939!

This field of hybrid corn was experimentally drill-planted in 20-inch rows, near El Paso, Illinois. The "Caterpillar" Diesel D2 Tractor is pulling a 27-foot finger-type weeder at fifth speed—cultivating 14 acres per hour average, laying by the crop! Four such timely, high-speed weedings were preceded by 2 times over with a rotary hoe—and by thorough Spring pre-cultivation with a field cultivator equipped with duckfoot shovels, before planting. Lower view shows the crop, ready for harvest. Note the clean condition of this field—that got an abnormally high amount of summer moisture, yet was untouched by slow, conventional row-crop cultivators.

Also note the density of plant growth and the heavy earing. Competent corn men have variously estimated the yield from 120 bushels per acre up (size of field, 80 acres). And producing this corn with fewer man and tractor hours (and these latter, modern Diesel tractor hours!) results in economy so drastic as to forecast possibilities of remarkable import to Agricultural Engineers!

CATERPILLAR

TRACTOR CO. PEORIA, ILLINOIS

DIESEL ENGINES TRACK-TYPE TRACTORS TERRACERS

A.S.A.E. Fall Program

(Continued from page 442)

South," by E. T. Swink; "The Use of Electric Traps in the Control of the Corn Borer," by G. A. Ficht; "Correlation of Utility and College Rural Electrification Programs," by R. U. Blasingame; and "Code Regulations for the Electric Fence," by F. W. Duffee.

Afternoon session features will include "What Agricultural Engineers are Contributing to Farm Electrification Research Results," by H. L. Garver; "Recent Developments of Agricultural Engineering Interest in the REA Program," by O. W. Meier; "Problems Now Facing Engineers in the Efficient and Economic Application of Electricity in Agriculture," by Geo. W. Kable; and "Ultraviolet and Infrared Energy in Agricultural Practice," by L. C. Porter. Progress reports of committees will be presented before the conclusion of this session.

A technicolor motion picture, with sound, entitled "The Middleton Family at the New York World's Fair," is to be shown in the evening. Any group round tables desired will also be scheduled at that time.

The Friday morning session offers "An Extension Program for Rural Electrification," by Roy E. Hayman; "How to Adapt Standard Single-Phase Electric Motors to Optimum Farm Use," by B. Parker Hess; and "New Developments and Trends in the Farm Refrigeration and Storage of Meats, Vegetables, and Fruits," by Geo. A. Rietz. Progress reports of committees will also be continued in this session.

A round table to provide an exchange of ideas and experiences in providing adequate electric wiring for the farm and farm home will be held in the afternoon, with Geo. W. Kable presiding. Contributions are scheduled from M. H. Lloyd, A. V. Krewatch, H. P. Richter, and G. E. Henderson.

Fire Protection Meeting

ANNOUNCEMENT is made of a meeting of the Farm Fire Protection of the National Fire Protection Association, to be held in Room 505 at the Stevens Hotel, Chicago, 9:30 a.m., December 5, 1939, and also of a meeting of the Agricultural Committee of the National Fire Waste Council which will be held in the same room at the same time on December 6.

Members of the American Society of Agricultural Engineers are cordially invited to attend these two meetings.

Tennessee Section Meeting Reflects Interest

THIRTY-FOUR members and guests, plus a representation of students, attended the first semiannual meeting of the new Tennessee State Section of the American Society of Agricultural Engineers, held at Knoxville, Friday, October 20.

Dr. M. Jacob, dean of the College of Agriculture, University of Tennessee, addressed the group and is reported to have indicated an intention to have the University, through its agricultural engineering department, the agricultural experiment station, and the Junior College in West Tennessee, take a strong lead in furnishing agricultural engineering educational facilities and assistance to the people of the state.

The papers on rural electrification, farm machinery, and erosion control aroused noteworthy interest and discussion.

April, 1940, was set as the approximate time for the next meeting of the Section.

Personals

E. L. Barger, associate professor of agricultural engineering, Kansas State College, presented a paper at the fuels and lubricants meeting of the Society of Automotive Engineers at Tulsa, Okla., on November 2, dealing with the problem of tractor fuels, and including a report of the work done in the direction of standard specifications for tractor fuels by the A.S.A.E. Committee on Tractor Fuels, of which he is chairman.

Hans G. Jepson is author of "Prevention and Control of Gullies," published as Farmers' Bulletin No. 1813 of the U. S. Department of Agriculture, superceding Farmers Bulletins Nos. 1234, 1697, 1737, and 1760.

Geo. W. Kable, editor, "Electricity on the Farm," was the banquet speaker at the Rural Electrification Conference at the A.&M. College of Texas, College Station, on October 27, and on November 2 spoke to the sales committee of the Southeastern Electrical Exchange at Atlanta, Georgia. He has been making an extensive tour by automobile, including several special calls to Oklahoma, Arkansas, Tennessee, and Virginia.

L. F. Livingston, manager, agricultural extension division, E. I. du Pont de Nemours & Co., during the past month has been on an extensive speaking tour, including states of the South and Northwest. His talks which have averaged almost one a day have been devoted mainly to the use of agricultural products in industry, and have been given before chambers of commerce, luncheon clubs, and student groups.

J. P. Schaenzer has been appointed head of the new rural service division recently established by the Edison Electric Institute, which division will act as a clearing house for information concerning rural electrification subjects, and "it will issue publications from time to time and motivate national promotional programs for the stimulation of coordinated efforts to encourage more complete electrification of rural customers of the utility companies." Mr. Schaenzer was more recently assistant director of the Committee on the Relation of Electricity to Agriculture.

C. H. Van Vlack is the writer of Iowa Agricultural Extension Circular 261, on "Selecting and Applying Paints."

J. W. Weaver, Jr., is senior author of Tennessee Agricultural Experiment Station Bulletin No. 170, on "Drying Hay in the Barn and Testing Its Feeding Value."

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the October issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

A. W. Cooper, instructor, Agricultural Engineering Department, Alabama Polytechnic Institute, Auburn, Ala. (Mail) 337 East Magnolia Ave.

Wm. A. Cornwell, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) SCS-27, Council Grove, Kans.

Maurice Donnelly, research project leader, Soil Conservation Service, U. S. Department of Agriculture, University of California. (Mail) 4425 Fourth St., Riverside, Calif.

H. T. Herrick, assistant chief, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture, Washington, D. C.

Frank J. Hoyt, 741 E. 3rd St., Tucson, Ariz.

Dale O. Hull, graduate fellow, agricultural engineering department, Iowa State College. (Mail) RR No. 2, Boone, Iowa.

Fred W. Kernen, lecturer, agricultural engineering extension department, University of British Columbia, Vancouver, B. C., Canada.

E. C. Mann, Jr., cruiser, Hercules Powder Company. (Mail) Thomasville, Ga.

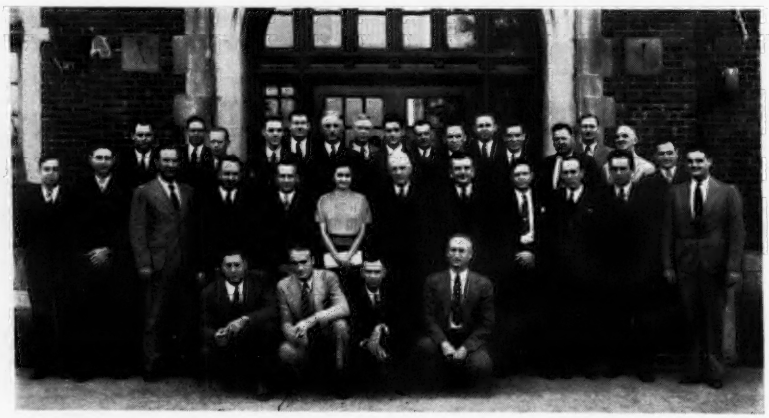
Samuel T. Moore, Jr., research assistant, agricultural engineering department, University of Georgia, Athens, Ga. (Mail) 1250 S. Lumpkin St.

Charles H. Reed, silo inspection, erection and design, Craine, Inc., Norwich, N. Y.

W. J. Ridout, Jr., rural service engineer, Kentucky and West Virginia Power Company, Pikeville, Ky.

James P. Stafford, Jr., research fellow, agricultural engineering department, Iowa State College, Ames, Iowa.

W. B. Wingfield, Jr., junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 404 Second Ave., Rome, Ga.



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The Minneapolis-Moline UDLX standard tread tractor pictured above uses a KED high compression engine. Piston lock screws, connecting rod bolts, flywheel bolts, differential pinion shaft, power shaft, differential shaft, cage bolts and all gears are made from SAE 3135, heat treated Nickel alloy steel. Belt pulley shafts are SAE 4620 Nickel-molybdenum steel.

Minneapolis-Moline Universal Z tractor harvesting rye with a pick-up attachment. The engine has a variable speed governor for maximum of 1,500 RPM. Speeds from 2.8 to 15.3 MPH. For longer service at lower cost per year than plain carbon steels, all gears are forged from SAE 3115 Nickel steel, carburized and heat treated.

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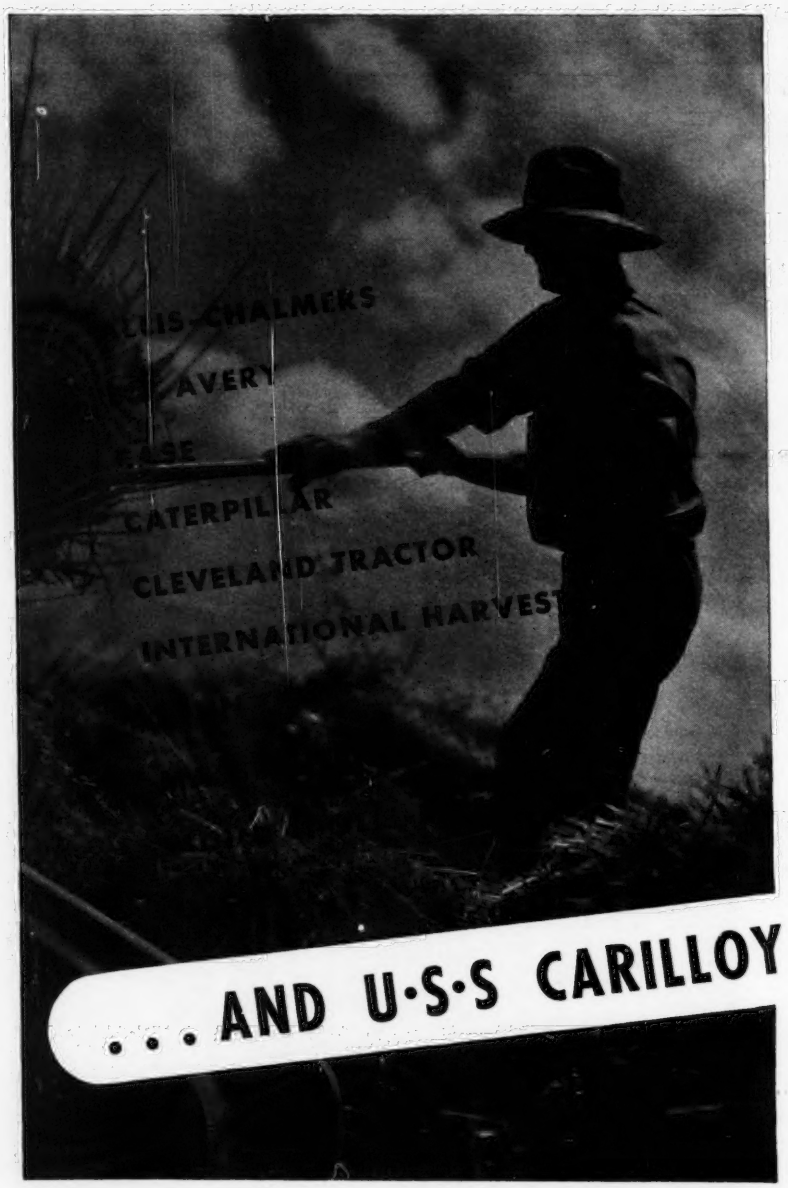

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ELECTRIC REFRIGERATION
the twig is bent
COLD STORAGE LOCKER PLANTS
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What will it cost?
ELECTRIC HELPERS FOR THE FARM FAMILY
How should I
LIGHT for the FARM
ELECTRIC MOTORS
What will electricity do for me?
MOTORS
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Have you up-to-date answers to these questions?

EVERY year more farm families are turning to their agricultural leaders for advice on the increasingly important subject of farm electrification. So rapid have been the improvements in this field that General Electric has recently revised 18 of its 31 rural-electrification bulletins in order to provide farm people with up-to-date answers to their many questions and problems. You will find it convenient to have these new publications on hand when your farm families ask for the latest information.

If you're planning rural-electrification meetings, you'll want to use General Electric's popular talking picture, "Bill Howard, RFD," or one of the four new sound slide films on farm wiring, lighting, refrigeration, and electricity and plant growth. Use the coupon below to order the bulletins or to ask about using the movie and slide films. If you have special questions, just write Agricultural Leaders Rural Electrification Service, General Electric Company, Schenectady, New York.

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- ☐ Farm Motors, GED-664
- ☐ Refrigeration on the Farm, 320-1106
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- ☐ Conditioned Air, 420-1555A
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- ☐ Please tell me how I can obtain, free of charge, your movie and slide films for use in my work.
- ☐ Will you please keep me posted on the latest developments in the field of farm electrification?

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521-37

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers thereof, whose names and addresses may be obtained on request to AGRICULTURAL ENGINEERING, St. Joseph, Michigan

LIST OF PUBLICATIONS ON THE SEASONING OF WOOD. (Cooperative with University of Wisconsin.) U. S. Dept. Agr., Forest Serv., Forest Prod. Lab., 1938, pp. [1]+20. This list includes publications that present the results of research of the Forest Products Laboratory on experimental and applied kiln drying, physical properties, air drying, and steam bending. It also contains a partial list of books on seasoning.

CHANGES IN FARM POWER AND EQUIPMENT: MECHANICAL COTTON PICKER, *R. L. Horne and E. G. McKibben*. Philadelphia: Works Prog. Admin. [U. S.], 1937, pp. XI+24, figs. [8]. This is the second report of the series noted above. Different types of pickers are described, and estimates as to costs, losses, etc., based on experimental machines in use are included. The probable effects of a successful picker on labor, size of farms, etc., are discussed.

COMPARISON OF THREE METHODS FOR DETERMINING THE BREAKING STRENGTH OF COTTON FIBERS, *M. A. Grimes*. (Tex. Expt. Sta.) Textile Res., 7 (1937), No. 3, pp. 145-148, figs. 2. The application to cotton fibers of a modification of the flat-bundle method for determining the tensile strength of rayon and silk fibers is described. Combed bundles of parallel fibers were placed within a ¾-in space in a cutting gage made from strips of transparent celluloid joined with a hinge of adhesive tape and were cut to a ½-in length, weighed, taped with drafting tape, and broken in a fabric breaking strength machine. The strength in pounds per gram of cotton was calculated by dividing the machine break by the weight of the cotton. The strength per cross section of area was determined from the formula: Strength $=$ $\frac{\text{machine break}}{\text{area}}$, when the area is calculated from the formula: $\text{Area} = \frac{\text{weight}}{\text{density} \times \text{length}}$

The modified method, which is known as the cut-weighed-taped method, was tested on 23 samples of cotton fibers, and the results were compared with those obtained by the Chandler bundle method by which the breaking strength per cross section area is determined on the basis of the circumference and with a third method by which the strength of an individual fiber is determined and the average of a large number of determinations is assumed to be the breaking strength. By statistical analysis of the data the cut-weighed-taped method yielded a score of 72 as compared to 73 for the Chandler and 58 for the other method. The modification of the flat-bundle method is deemed as accurate as the Chandler bundle method, and has the advantage of saving considerable time and energy and not requiring the special cutting jaws and wrapping device.

THE BEHAVIOR OF SOIL MATERIALS IN WATER RETAINING STRUCTURES, *E. W. Lane*. (Iowa State Col.) Soil Sci. Soc. Amer. Proc., 1 (1936), pp. 367-375, figs. 4. The author points out that earth dams and masonry dams on earth foundations depend for their security upon the properties of soils. The failure of such structures is discussed from the point of view of soil behavior, and suitable construction methods are considered.

SOIL CHARACTERISTICS IN RELATION TO HIGHWAY ENGINEERING; *C. A. Hogentogler and P. Rapp*. Soil Sci. Soc. Amer. Proc., 1 (1936), pp. 377-382, figs. 5. The authors discuss eight types of soil tests, as follows: (1) Exploration of natural soil formations; (2) investigation of size, character, and physical properties of soil solids; (3) determination of the physical characteristics of artificial soil-water mixtures; (4) investigation of the properties of densified or compacted soil with or without admixtures; (5) determination of the mechanical properties of soil with natural moisture content and structure; (6) determination of the mechanical properties of soil with disturbed structure but natural moisture content; (7) the flow of gravitational and capillary moisture through soils as they affect the design of drainage systems; and (8) investigations of colloidal surface characteristics. In addition to these tests and other indications, he takes up also a classification based on mechanical analysis and physical characteristics.

THE INFLUENCE OF SOIL CHARACTERISTICS ON DRAINAGE AND IRRIGATION PRACTICES, *W. Gardner*. (Utah Expt. Sta.) Soil Sci. Soc. Amer. Proc., 1 (1936), pp. 383-392, figs. 17. This contribution presents a mathematical analysis of some of the relations between irrigation and available moisture supply and between drainage, erosion, and flooding. The discussion is based largely upon the Darcy law, originally derived from the movement of water in a horizontal tube filled with homogeneous sand, the velocity of flow having been shown to be "directly proportioned to the difference in pressure head and inversely proportional to the length of the tube, $v = k \frac{(h_1 - h_2)}{L}$. In its general form, this law states that the velocity of the percolating stream regarded as a distributed vector point function is directly proportional to the gradient of the aggregate potential, a distributed scalar point function Φ made up of the two terms, p/ρ and ϕ, $\Phi = p/\rho + \phi$, in which p represents the hydrostatic pressure, ρ the density of water, and ϕ the gravity potential. In this more general form, $v = -k \Delta \Phi$, the equation is adapted to a broader application." In the first of these equations h_1, h_2 and L are, respectively, the original and the diminished pressure heads and the distance through which the water moves in the sand.

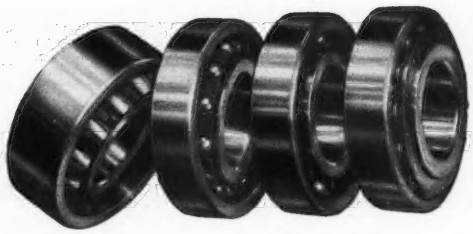
CONSERVATION AND USE OF SOIL MOISTURE AT MANDAN, N. DAK., *J. C. Thysell*. U. S. Dept. Agr., Tech. Bul. 617 (1938), pp. 40, figs. 4. Soil moisture was determined for 20 yr in 1-ft sections to a depth of 6 ft on land cropped to wheat and corn under different cultural methods and on two soils of widely different texture and water-holding capacities. Storage and use of soil moisture are recorded on the basis of divisions of the year into two major periods, designated as growing and dormant periods, and four minor periods, seeding to early June, early June to harvest, harvest to late fall, and late fall to seeding. Water determined as a percentage of the dry weight of the soil is converted to inches by the formula

$$\text{inches of water per 1-ft layer} = \frac{mw}{5.196},$$

in which m is the percentage of water and w is the weight of a cubic foot of soil. One-half the quantity of water represented by the moisture equivalent to a depth of 6 ft is designated the normal point of field reduction, and water above that quantity is used as the quantity available for crop use. Averages of from 2 to 5 in more water were available under alternate cropping than under continuous cropping. From 1 to 2 in more water was available under all conditions in the light soil than in the heavy soil. Field water requirement, based on the difference in the water content of the soil at seeding and harvest times, plus the precipitation during that period, is stated in terms of acre-inches of water used in the production of 1,000 lb of field-cured crop. During the whole fallow period 20 per cent of the precipitation was saved. The gain or loss in the water content of the soil during minor parts of the fallow period appeared to be definitely identified with specific conditions of surface cover or soil. An average saving of 1 in of water by plowing fallow June 1 instead of July 1 resulted in an increase of 6.6 bu of wheat per acre.

WATER CONDITIONING FOR GREENHOUSES, *C. H. Spurway and C. E. Wildon*. Michigan Sta. Circ. 166 (1938), pp. 10, figs. 2. Herein is presented a description with discussion as to operation of an apparatus designed for neutralizing the carbonate alkalinity or carbonate hardness of water. The effect of carbonate hardness in water on plants and the underlying principles of water conditioning are discussed. In general, the conditioned water maintained the pH value of the soils at about the same level or slightly lower than did distilled water, and increased markedly the soluble phosphorus content of the soils.

(Continued on page 450)



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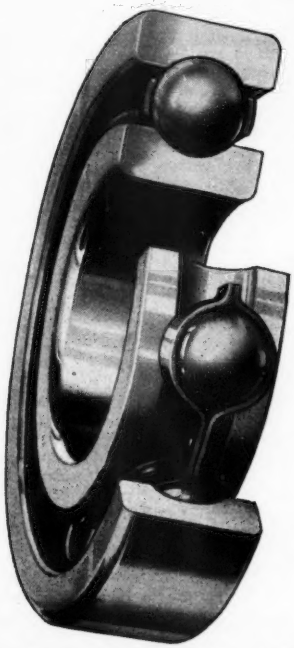

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Agricultural Engineering Digest

(Continued from page 448)

A MACHINE FOR CLEANING TOBACCO SEED, *L. S. O'Bannon and W. D. Valleau.* Kentucky Sta. Bul. 381 (1938), pp. 101-112, figs. 5. The tobacco seed cleaner described is of the blower type and does not employ sieves. It separates heavy and light seed effectively, and has been found satisfactory for cleaning both small and large lots of seed.

THE PAINTING OF SAP BUCKETS AND OTHER EQUIPMENT USED IN THE PRODUCTION OF MAPLE SYRUP, *C. O. Willits.* New York State Sta. Circ. 182 (1938), pp. 4. Practical information is given on the subject.

RETIRED REFRIGERATOR CARS FOR AIR AND ICE-COOLED STORAGE.—A PRELIMINARY REPORT, *H. A. Cardinell.* Michigan Sta. Quart. Bul., 20 (1938), No. 4, pp. 240-247, figs. 5. An account is presented of the securing, equipment, and utilization of an old refrigerator car as a fruit cooling and storage plant. The succession of fruits—cherries, peaches, and apples—were handled profitably.

TECHNOLOGY OF EROSION CONTROL, *M. L. Nichols.* (U. S. D. A.) Soil Sci. Soc. Amer. Proc., 1 (1936), pp. 393-399. This discussion takes up general principles of erosion control; field practice in various areas, including the Coastal Plains, the Black Belt of Alabama and Mississippi, and the Piedmont area; and general applications of the erosion control technics which have arisen under the various local conditions considered.

REMOVAL OF LEAD SPRAY RESIDUES FROM APPLES GROWN IN THE SHENANDOAH-CUMBERLAND VALLEY, *M. H. Haller, C. C. Cassil, C. W. Murray, J. H. Beaumont, and E. Gould.* (Coop. Md. and W. Va. Expt. Stas.) U. S. Dept. Agr., Tech. Bul. 622 (1938), pp. 32, fig. 1. Studies conducted in 1934 with Jonathan, Grimes Golden, Delicious, Stayman Winesap, and York Imperial apples, and in 1935 with Stayman Winesap alone, indicated that the variety is not an important factor in the amount of residue or ease of removal. The addition of mineral-oil emulsion to the second-brood cover sprays of arsenate of lead greatly increased the lead residues and the difficulty of cleaning. When lime was omitted from the late cover sprays, the amount of residue and difficulty of removal were greatly increased. Heating the washing solution was not found uniformly necessary if an effective wetting agent was added to the acid solution and if mineral oil had not been used more than twice in the late cover sprays. Lead residues remaining after certain washing treatments were closely correlated with residues at harvest, and the percentage removed by a given washing treatment was fairly uniform, suggesting that the necessary washing treatment may often be approximated from the residue at harvest. Greater benefit was obtained from heating combined acid wetting-agent solutions than acid solutions alone. No benefit was obtained from the addition of 1 per cent of common salt to a 1.5 per cent hydrochloric acid solution. In the case of apples sprayed with lead arsenate and mineral-oil emulsions, the addition of 1 gal of light mineral oil to 100 gal of heated acid solution in a flood-brush machine was beneficial. Heated sodium silicate solutions were less effective than heated acid solutions, except where lime had been omitted from the late cover spray. Storage for from 4 to 5 mo at 32 F increased the difficulty of removing lead residues, particularly when acid alone was used. Washing apples did not increase decay in storage at 32 F, whether packed wet or dry. York Imperial showed slight lenticel injury from the acid wetting-agent process and heat injury when washed at 110 F for 1.5 min and considerable injury at 120 F for 1 or 1.5 min.

A POSSIBLE NEW TOOL FOR THE INDUSTRY—STERILIZATION BY RADIATION, *O. F. Garrett and R. B. Arnold.* (N. J. Expt. Stas.) Milk Plant Mo. 27 (1938), No. 8, pp. 39, 40, 42. This report of preliminary investigations presents evidence that ultraviolet irradiation (Sterilamp) may be satisfactorily employed for the sterilization of dairy plant equipment, utensils, packages, wrappers, etc., and the floors, walls, and even the air in the storage rooms, processing plants, barns, etc., and for the treatment of cheese in curing rooms.

SOIL CHARACTERISTICS INFLUENCING THE MOVEMENT AND BALANCE OF SOIL MOISTURE, *L. D. Baver.* (Mo. Expt. Sta.) Soil Sci. Soc. Amer. Proc., 1 (1936), pp. 431-437, figs. 3. The author presents a discussion designed to point out that the soil plays a major role in the hydrologic cycle, and states that it is necessary to evaluate the complex variable of soil-water movement in its relation to soil properties before a thorough understanding of water conservation and erosion control is possible.

COMMUNITY BUILDINGS FOR FARM FAMILIES, *B. Halbert.* U. S. Dept. Agr., Farmers' Bul. 1804 (1938), pp. 11+41, figs. 36. This supersedes Farmers' Bulletin 1173 and brings together the experience of recent projects in the development of community-building programs. Its purpose is to acquaint rural communities that need these buildings with successful building programs in other places.

SOIL-DEPLETING, SOIL-CONSERVING, AND SOIL-BUILDING CROPS, *A. J. Pieters.* U. S. Dept. Agr. Leaflet 165 (1938), pp. 8, figs. 3. The author describes as "soil depleting" any crop which brings about destruction of the organic matter (as by requiring excessive cultivation) or so exposes the soil as to cause the loss, by erosion, of minerals in excess of those taken off in the crop itself. Non-cultivated crops conserve soil organic matter, regarded as the most important point, and their close-growing habit protects from erosion. Soil-building crops are those which increase the organic matter supply. For soil building the author considers grass sod the most important. However, "green manuring combined with erosion-control practices should maintain the productivity of the soil."

EFFECTS OF ULTRAVIOLET RADIATION UPON GERMINATION AND SEEDLING DEVELOPMENT, *H. W. Popp and F. B. Charlton.* Pennsylvania Sta. Bul. 366 (1938), pp. [2]+50, figs. 17. Long exposures (over 2 hr) to the unscreened mercury vapor arc had no effect on dry seeds but reduced the rate and final germination of soaked seeds. Also at 2 min or less, or at any length exposure through the screens tried, there was no effect on germination of the seeds studied, including white mustard, buckwheat, radish, turnip, cucumber, pigweed, and curled dock. Exposures of 15 min or more per day at 50 cm from the unscreened arc proved destructive to seedlings after one or more treatments and were fatal if continued for 10 days. This destructive action was restricted to the region below 300 mμ. Exposures of 2 min at 50 cm were less injurious but had a marked formative effect on the seedlings, and the epidermal tissues were injured though the plants were not killed. Plants in the dark were more markedly affected than in the light. Still shorter exposures caused reduced stature but not to so marked a degree. Seedlings exposed 2-4 min per day were lower in fresh and dry weights and in percentage of moisture than controls, and were lower in total carbohydrates and reducing sugars but somewhat higher in starch. No significant difference was noted between irradiated plants and controls when seedlings were exposed at the same distance at which the unscreened arc was used and for the same time, or under the same total intensity of radiation to the ultraviolet region between 300 and 400 mμ, to this region in combination with infrared radiation or to the latter alone. No significantly greater elongation of seedlings was obtained either by extremely short irradiation with the unscreened arc or by short irradiations with any other region of the ultraviolet studied than occurred in nonirradiated controls. With longer irradiation the long-wavelength ultraviolet region tended to stunt the plants. In general, both the destructive action and the formative effects on stature and general development decreased with increasing distance from the lamp and with decreased time of exposure. The most notable effect of the ultraviolet region of the spectrum was to reduce the stature of the plants, and this effect increased with decreased wavelength, with increased length of exposure, and with increased intensity.

THE USE OF ELECTRICITY IN AGRICULTURE, *L. J. Smith, H. N. Colby, and H. L. Garver.* Washington Sta. Bul. 368 (1938), p. 10. Studies on comparative cost of cooking with various sources of heat, cost of drying hay, cost of electric heating of water, placement of heating cables in hotbeds, and the use of electric light in stimulating egg production are very briefly reported.

EFFECT OF SOIL CHARACTERISTICS ON PLANT DEVELOPMENT IN RELATION TO WATER CONSERVATION, *M. R. Huberty.* (Calif. Expt. Sta.) Soil Sci. Soc. Amer. Proc., 1 (1936), pp. 439-446. The author of this contribution discusses availability of soil moisture to plants, cultivation, organic matter, soil temperature, soil organisms, soil solution, soil air, and texture, structure, and profile development with respect to their influences upon plant moisture and in the light of information derived from the more than 70 papers cited.

PROVISIONAL PROBLEM AREAS IN SOIL CONSERVATION RESEARCH IN THE UNITED STATES, *E. A. Norton, R. V. Allison, and G. D. Scarseth.* Soil Sci. Soc. Amer. Proc., 1 (1936), pp. 495-503, pl. 1. A brief preliminary report tabulates 80 of those areas already sufficiently studied to permit of their classification in the groups of serious, moderate, and slight conservation difficulty. Of each area or land class so tabulated the topography, climate, original vegetation, predominant land use, years of predominant land use, type of erosion, soil characteristics, and principal soil series are shown.

(Continued on page 452)

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HYDROLOGIC INTERRELATIONS OF WATER AND SOILS, *R. E. Horton.* Soil Sci. Soc. Amer. Proc., 1 (1936), pp. 401-429, figs. 8. In this systematic analysis of available information and needed investigation the author's main object has been "to point the way whereby empirical or purely statistical analyses of water-soil relationships may be replaced by studies along the lines of the physical processes involved."

Surface runoff phenomena are considered with reference to a unit strip, a strip of ground of unit width following the slope from the watershed line to an outflow channel. "In other words, this paper deals with microhydrology as distinguished from the more usual machrohydrology, which deals with entire drainage basins or other geographic areas.

"One important result is that conclusions derived from runoff plat experiments cannot be directly applied to larger areas. Such experiments will give correctly the infiltration capacity and volume of depression storage for a larger similar area, but since velocity of overland flow, depth of surface detention, total runoff, and soil erosion vary with length of overland flow, the results of plat experiments must be multiplied by a scale factor to make them applicable to larger areas."

LAND FACTS ON THE SOUTHERN PLAINS, *G. K. Rule.* U. S. Dept. Agr., Misc. Pub. 334 (1939), pp. [4]+22, figs. 13, map 1. This is a nontechnical and very general description of the soil conditions and needs found and of the treatments demonstrated in region 6 of the Soil Conservation Service. An attached map covering 10 problem-area groups "represents the first attempt to isolate and label those bodies of land where the soil, climate, and appropriate farming practices are somewhat similar."

SOIL INVESTIGATIONS BY THE CALIFORNIA STATION. (Partly coop. U. S. D. A.) California Sta. [Bien.] Rpt. 1937-38, pp. 1-9, pls. 2. These are noted briefly under the captions—need for soil surveys, new soil surveys, natural land classifications, erosion control measures prove adequate, cover crops prove efficient, use of mechanical controls, drainage problems again troublesome, alkali lands reclaimed, soil permeability studies, soil colloids, and irrigation and soil salts.

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Literature Received

SIMPLIFIED MECHANICS FOR GIRLS, by Edith Louise Allen. Paper bound, 107 pages, 91 illustrations, 6x9 in. A text, laboratory manual, and handy reference guide on the operating principles, purchase, use, care, and repair of household equipment ranging from extension cords and kerosene lamps to lawn mowers, refrigerators, and dish-washing machines. Each chapter is divided into information units and job assignments. Chapters cover power and force, utilization of electricity in the home, lighting, insulation and refrigeration, heating, water supply and sewage disposal, laundry work and house cleaning, and measures and regulators. Information is also given on points to consider in the selection of equipment, and brief tables on weights and measures are included. Manual Arts Press, $0.68.

LAND DRAINAGE AND RECLAMATION, by Q. C. Ayres and Daniels Scoates, Second edition. Clothbound, xi+496 pages, 6x9 in, 316 illustrations, 48 tables, indexed. This text and reference has been brought up-to-date, from its original publication in 1928, by major changes in the introduction, contraction of the chapter on land clearing, expansion of material on control of erosion into three chapters and inclusion of a discussion on soil conservation districts in the chapter on drainage districts. Many other chapters were revised in minor details, with addition of new material, illustrations, and problems. Subjects covered include measuring distances, surveying with steel tape, levels and level rods, leveling, adjusting levels, lines and angles, topographical surveying, computing areas, land surveying, drainage properties of soils, rainfall and runoff, open-ditch design, open-ditch location and construction, open-ditch maintenance, earth dams and levels, drainage districts, useful principles of law, explosives and their use, land clearing, control of soil erosion, terracing, control of gullies, subsurface drainage, location of tile drains, design of tile drains, selection of tile, installation of tile, drain tile accessories, estimating cost of tile drainage and special methods of drainage. Practical tile drainage problems are given in an appendix. McGraw-Hill, $4.00.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

ASSISTANT AGRICULTURAL ENGINEER with farm experience and good basic engineering and agricultural training wanted for work with missionary college in India. Young, adaptable man preferred. Must have missionary purpose as well as technical training. Minimum technical qualification is bachelor of science degree in agricultural engineering. Master's degree highly desirable. Appointee without advanced degree must expect to get it during first furlough. General interest in all phases of agricultural engineering preferred to high degree of specialization. Duties mainly teaching. Ability to cooperate with other members of staff, and to use English language correctly is important. Interested persons should apply to the Candidate Department, Board of Foreign Missions, 156 Fifth Ave., New York City.

POSITIONS WANTED

AGRICULTURAL ENGINEER graduating last June from agricultural engineering course, with experience in CCC drainage camps and in shop work at the Louisiana Agricultural Experiment Station, desires employment where there is opportunity for promotion. Salary no object. 22 years of age. Single. Will go anywhere. PW-310

AGRICULTURAL ENGINEER, with B. S. degree from Rutgers University (1937) and M. S. degree from Virginia Polytechnic Institute (1939) possessing diversified agricultural engineering training, with a major in farm power and machinery, desires employment in institutional instructional, research, or extension work, or with commercial concern, in any branch of agricultural engineering. Age 24. Health excellent—no defects. Single. Rural background. Complete credentials furnished upon request. Best of references. PW-311

AGRICULTURAL ENGINEER, 1939 graduate with a bachelor's degree and a farm background, desires a position in any field of agricultural engineering. Has had summer experience with SCS and AAA. Age 20. Single. PW-312